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ZAMBIA POWER SECTOR ASSESSMENT

February 2018

ACRONYMS

Acronym	Definition
AfDB	African Development Bank
BSA	Bulk Supply Agreement
CEC	Copperbelt Energy Corporation
DFID	Department for International Development
ERB	Energy Regulatory Board
EU	European Union
GDP	Gross Domestic Product
GET FiT	Global Energy Transfer Feed-in Tariff
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
GWh	Gigawatt hours
HV	High voltage
IDC	Industrial Development Corporation
IFC	International Finance Corporation
IPPs	Independent Power Producers
ISMO	Independent System Market Operator
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
KPI	Key Performance Indicator
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
LHPC	Lunsemfwa Hydro Power Company
LV	Low voltage
MV	Medium voltage
MW	Megawatt
NARUC	National Association of Regulatory Utility Commissions
OPPPI	Office for Promoting Private Power Investment
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PV	Photovoltaic
REA	Rural Electrification Agency
REFiT	Renewable Energy Feed in Tariff

Acronym	Definition
REEEP	Renewable Energy and Energy Efficiency Partnership
REMP	Rural Electrification Masterplan
ROCE	Return on Capital Employed
SAPP	Southern African Power Pool
SIDA	Swedish International Cooperation Agency
USAID	United States Agency for International Development
USAID SAEP	United States Agency for International Development Southern Africa Energy Program
USD	US Dollar
ZDA	Zambia Development Agency
ZESCO	Zambian Electricity Supply Corporation
ZCCM	Zambia Consolidated Copper Mines
ZCCM-IH	Zambia Consolidated Copper Mines – Investment Holdings

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EXECUTIVE SUMMARY

This report identifies the challenges facing Zambia's power sector, particularly those confronting the Zambian Electricity Supply Corporation Limited (ZESCO). The report was commissioned by the United States Agency for International Development Southern Africa Energy Program (USAID SAEP). Its purpose is to serve as a fact base for the sector, and to inform stakeholder discussions to identify potential solutions and actions.

A careful examination of the sector reveals that Zambia is unlikely to meet its aspirations for 2030 in terms of new megawatts (MW) and connections – reaching 7.2 GW in generation capacity (from 2.8 GW currently) and a 66 percent electrification rate (from 27 percent currently) – unless it can transform ZESCO's performance and addresses various gaps in institutional design. Transforming ZESCO's performance to attain commercial viability is critical to accelerate delivery of electrification, address the potential supply-demand gap, and meet Zambia's power sector aspirations. To achieve commercial viability, ZESCO would need to develop a credible plan to address at least five issues: capacity constraints, insufficient revenue collection, high transmission and distribution losses, the absence of cost-reflective tariffs and balance sheet constraints. It would then need to create an effective delivery mechanism to achieve this plan. The proposed creation of an Independent System and Market Operator (ISMO) – requiring government support and guarantees to sign purchase agreements – would not have the desired effect of levelling the playing field unless ZESCO is commercially viable.

Zambia also needs to clarify the contributions it requires from the private sector in terms of, e.g., new capacity investments and off-grid electrification. By developing an Integrated Resource Plan (IRP) and a comprehensive off-grid electrification framework, Zambia can bring in the private sector in a sustainable way.

This report draws on findings from 25 meetings with stakeholders in Zambia, and references over 30 existing reports on the country's power sector. The in-country United States Agency for International Development (USAID) mission, the Power Africa Advisors, and stakeholders from the Zambian development partners helped to develop the key analyses. It provides initial insights based on publicly available information as of 2017, and draws largely on 2015 data to ensure consistency across analyses. The 2015 information is complemented with additional sources dating back to 1997 and forecast to 2030. Data are primarily drawn from Zambian official reports, including from the Ministry of Energy, the Energy Regulatory Board (ERB), the Rural Electrification Agency (REA) and ZESCO's 2015 integrated report and 2016 statistical report. However, several elements could not be confirmed without access to ZESCO's management and ZESCO's managements' accounts. Once the USAID Southern Africa Energy Program (USAID SAEP) and ZESCO sign the Letter of Collaboration, ZESCO management will be engaged and further insights could be developed.

The main findings in each of the six chapters of the report follow.

POWER IN ZAMBIA

At 706 kilowatt-hour (kWh) per capita, Zambia's power consumption is below expectations relative to its economic and social potential when compared to that of peer countries. Zambia is the 18th largest economy in Africa, with a population of 15.7 million people and a GDP of USD 20.5 billion (2016). Today, approximately eleven million Zambians have no access to electricity, and those that do have access (27 percent) face the risk of power outages during drought seasons. Zambia's average electricity consumption per person (706 kWh per capita) is two to three times lower than that of other resource-rich economies such as Peru, Chile, Namibia, and South Africa.

Zambia's total installed capacity in 2016 was 2,827 MW. This is insufficient in drought years and does not adequately allow for economic growth. The country relies mainly on hydropower (84 percent of its installed capacity) from 12 plants, three of which accounted for 81 percent of electricity production in 2016 (Kafue Gorge, Kariba North, and Kariba North Extension). Given the significant supply of water resources in Zambia estimated at 6,000 MW of hydro potential, its focus on hydroelectricity is understandable.[1] However, this makes it vulnerable to droughts; two severe droughts occurred in the past fifteen years, most recently in 2015 and 2016. ZESCO's management of water resources in 2014-2015 exacerbated the impact of low rainfall in

[1] *Freedom to Create*, a policy report on the electricity sector in Zambia, 2016, Zambia Development Agency, energy sector profile, 2014, p.3

2016. The overuse of the Kariba Dam in the previous two years lowered reservoir levels, leaving a low base in 2016. This occurred because ZESCO added the Kariba North Extension in 2014 with a 360 MW installed capacity (two 180 MW turbines), but it ran the turbines extensively and depleted water reserves.[2] As a result, Zambia had a shortage of 500 MW in 2015 (eighteen percent of capacity) and nearly 1,000 MW in 2016 (35 percent of capacity). During years of regular rainfall, Zambia's power supply can meet the current peak demand of 2,287 MW. Historically (2001 to 2015), peak demand and installed capacity tracked one another, growing at approximately 3.29 percent per year. As Zambia grows, power demand will rise. Going forward Zambia will not be able to sustain the economic growth rates forecast in the 2017 Zambian Stability and Growth Program, which anticipates that GDP will increase around five percent per annum.[3]

Zambia's national grid mainly supports power flows from hydro stations in the south to the Copperbelt province in the north where the mines are located. The grid will require additional investment to enable future demand growth and the integration of variable renewable sources.[4] The Zambia national grid is composed of 4,650 kilometres (km) of 330 kilovolt (kV) lines. There are 385 km of 220 kV lines serving as interconnectors with the neighboring Democratic Republic of Congo (DRC), Namibia, and Zimbabwe, 1,054 km of 132 kV lines, and 721 km of 88 kV lines, mainly in the Lusaka area. In addition, the CEC has 246 km of 220 kV lines. The majority of power flows within the country from hydropower stations in the south to the Copperbelt in the north to feed the mines and main load centres. The country will need to invest in the grid to support its increasing consumption and economic growth, and to integrate intermittent renewable energy. According to the Ministry of Energy and ZESCO, the grid has capacity for only 700 MW of new intermittent renewable generation. The implication is that any capacity above that level might not be integrated and dispatched. The assumptions supporting this calculation were not available.

The Zambian authorities aspire to more than double current capacity and electrification rates by 2030. Despite the absence of an IRP, various official documents offer generally consistent targets. The 2008 Rural Electrification Masterplan (REMP) developed by the REA and the 2010 Energy Sector Roadmap owned by the Ministry of Energy outline Zambia's aim to increase operational capacity from 2.8 gigawatts (GW) today to 7.2 GW by 2030, increase electrification from 27 percent to 66 percent, and extend the grid by 4,055 km of transmission lines. However, these documents may be outdated, as they were drawn up approximately ten years ago.

STRUCTURE AND INSTITUTIONS

ZESCO is a vertically integrated utility and functions as the single buyer and system operator for Zambia's power sector. In 1995, Zambia began a set of structural reforms in 1995 to transition from a single utility (ZESCO) and to encourage private-sector participation along the value chain. Today, however, ZESCO still owns 81 percent of installed generation capacity. Privatization started with the state-owned copper mining company and its power assets to create the Copperbelt Energy Corporation (CEC). Four independent power producers (IPPs) subsequently established a presence and accounted for 19 percent of installed capacity in 2016. In 2015, the Industrial Development Corporation (IDC) and the International Finance Corporation (IFC) signed an agreement to explore the development of two large-scale solar projects through Scaling Solar. The first phase of this program (Scaling Solar I, 100 MW) is nearing financial close but faced delays.

Recent reforms have sought to encourage private-sector participation further. The latest set of reforms underway in 2017 include creating a Renewable Energy Feed-In Tariff (REFiT) program complete with a standardized power purchase agreement (PPA) and the review of three bills, the Electricity Act of 1995 (first amended in 2003), the Energy Regulation Act of 1995 (first amended in 2003), and the Rural Electrification Act of 2003. The Cabinet also appointed a taskforce co-chaired by the Ministry of Energy and the Ministry of Finance to look into transforming ZESCO. Its goal is to ensure that ZESCO becomes a viable, competitive utility.

Historically, development partners have played a critical role in facilitating Zambia's power sector reforms and they continue to contribute to the sector's operations and expansion. They frequently finance infrastructure development and provide technical

[2] Interviews with local stakeholders and press searches

[3] Ministry of Finance

[4] "Variable renewables, such as wind, wave, tidal, solar, and run-of-river hydro, share a characteristic that distinguishes them from conventional sources of energy: their output varies according to the availability of the resource. This variability represents an additional challenge in terms of their integration in power systems." From the International Energy Agency, Empowering variable renewables, 2008, p.2

assistance. Four main development partners were engaged in the discussions that produced this report: the World Bank, the Swedish International Cooperation Agency (SIDA), USAID, and the African Development Bank (AfDB).

LONG-TERM SUPPLY AND DEMAND BALANCE

No IRP currently exists that sets out Zambia's future load forecasts, reserve margins, and supply options. Thus, projections of the sector's supply and demand balances are based on a set of assumptions and the resulting scenarios rather than on a unified view held by Zambian authorities. This report provides a perspective on Zambia's supply and demand balances by comparing the sector's future required capacity forecasts with the projects in the pipeline for the Office for Promoting Private Power Investment's (OPPPI). The analysis revealed a potential short-term demand-supply gap (2017 to 2022) that could range from 90 MW to 600 MW and could peak at about 1,000 MW in the event of a severe drought. In the longer term (2022 to 2030), Zambia's large pipeline of power projects would meet its domestic capacity requirements until 2029 based on the historical growth trajectory. However, in the high-growth scenario, the country faces a widening gap in 2029 that would reach 1.4 GW (at peak load and excluding intermittent power).

CHALLENGES TO ZESCO'S COMMERICAL VIABILITY ALONG THE VALUE CHAIN

Although the sector has been opened to further investment, more needs to be done to ensure that Zambia can meet its aspirations. In particular, ZESCO's ability to deliver future capacity and to drive electrification needs to be boosted. Five major challenges limit ZESCO's and the sector's ability to deliver future MW:

1. **Capacity constraints due to inadequate current generation.** This is driven by vulnerability to drought, delays in the delivery of new capacity, and the over-utilisation of water reserves at Kariba Dam. The country's reliance on hydro constrains capacity during periods of low rainfall – this has occurred twice in the past 15 years. During the latest drought (2015 to 2016), plant availability remained at 88 percent but capacity factors dropped to 53 percent. As a result, ZESCO's cost of sales increased because of the expensive emergency power contracts in force with its Southern Africa Power Pool (SAPP) partners. In addition, while ZESCO's generation capacity is adequate in normal years, it does not allow for further growth.

2. **A strained grid**. Transmission losses have increased over the last few years (six to seven percent in 2015 versus an ERB target of five percent) and distribution losses are high (eleven percent based on ZESCO's 2015 and 2016 operational key performance indicators (KPIs) and stakeholder estimates).[5] Although other African utilities suffer similar losses and they are in line with the ERB's KPIs, the trajectory indicates increasing strain on the grid and raises concerns about ZESCO's ability to integrate intermittent renewable power supplies, such as solar power.

3. **Insufficient revenue collection.** In 2015, defaults from mining customers and the government were high and ZESCO increased its provisions for bad debts approximately 3.5 times from 2014 to 2015. Collection issues reduce the operating profits ZESCO needs to make operations economically viable and its ability to obtain an appropriate cost-reflective tariff.

4. **Absence of cost-reflective tariffs.** The tariff base is low (absolute and relative to peers), tariff increases trail inflation (partly because ZESCO has not met the ERB's performance KPIs), and high losses have not been factored fully into tariffs. At current operational performance levels, the average revenue ZESCO earns per kWh is slightly higher than the cost of production per kWh, leaving no margin for asset maintenance or expansion.

5. **Deteriorating ability to finance future growth.** The expansion of ZESCO's debt burden and a decline in net income raise concerns about its ability to meet additional debt payments going forward. ZESCO's debt-to-equity ratio increased 2.6x between 2011 and 2015, which reflected increases of 1.47x from 2011 to 2012, and 1.74x from 2012 to 2015. At the same time, ZESCO's interest coverage ratios declined sharply from 52.7x in 2012 to 1.39x in 2015. This combination could negatively impact ZESCO in two ways. It could prevent ZESCO from raising funding independently for future growth rather than relying more on government funding or guarantees or similar

[5] 2015 data are used because the transmission losses were excluded from the 2016 KPI rating

backstopping instruments. It could also prevent ZESCO from being a credible counter-party for IPPs and/or providing a counter-party balance sheet to enable private-sector investment.

This trajectory has worsened over the past five years. If the trend continues it could have significant implications for ZESCO and Zambia's power sector in the near term. Firstly, it is unlikely that ZESCO can sustain the investments needed to meet Zambia's demand for electricity in the near-term. Secondly, it is unlikely that ZESCO can be considered a creditworthy off-taker for potential private-sector power producers. Thirdly, the proposed creation of an ISMO (which would need government support and guarantees to sign purchase agreements) may not have the desired effect of levelling the playing field if ZESCO is not commercially viable. Finally, ZESCO's ability to put forward a credible plan to achieve commercial viability (with an effective delivery mechanism) will be critical for the sector's growth and aspirations.

CHALLENGES IN DELIVERY OF ELECTRIFICATION

ZESCO's role in the power sector is critical to deliver electrification in Zambia. ZESCO, REA, the ERB, and other Zambian power sector stakeholders will need to work together to address several issues.

Delays in grid electrification are driven by the slow resolution of the connection backlogs in urban areas, issues with completing last-mile connections in rural areas due to a lack of financial incentives for ZESCO, and lack of funding and an unclear mandate for REA. Population density is low in Zambia at twenty people per square kilometer, and the average distance between rural households can be even greater. Although central grid extension (driven by REA and ZESCO) can provide rural communities with electricity, the costs of these connections are high. Most of the rural population lives below the poverty line and is expected to consume less than the current level of free basic electricity in Zambia (200 kWh). As a result, ZESCO's incentive to deliver last-mile connections in rural areas requires cost-reflective tariff allocations from ERB, and REA's funding for and mandate on last-mile connections seems unclear. In addition, ZESCO has a high backlog of connections in urban areas with an average connection time of up to 150 days.[6]

Off-grid technology providers are just starting to penetrate the market and have faced scale-up constraints. At least seven off-grid solar players aspire to deliver more than 500,000 connections by 2022.[7] Several barriers would need to be overcome to help them achieve scale, including regulatory framework challenges (e.g., lack of recent commitment on role off-grid in national electrification plans, lack of level playing field, lack of documented process to clarify grid interaction rules and inconsistent application of import duty exemptions), customer ability to pay and awareness and supply chain, route to market (cost of remote expansion), and access to finance. In 2016, SIDA, Power Africa, and the Renewable Energy and Energy Efficiency Partnership (REEEP) launched the Beyond the Grid Fund for Zambia to accelerate off-grid market development and support five existing market players to provide electricity access to one million Zambians.

The ERB, REA, ZESCO, and the Ministry of Energy (with customs and other stakeholders) could collectively address the two important implications of these issues:

1. If Zambia aims to attain 66 percent electrification by 2030 at a world-class pace (comparable to South Africa, which increased electrification from 20 to 40 percent in eight years, and Vietnam, which increased electrification from twenty to over 80 percent in nine years) it must clarify the mandates and incentives for REA or ZESCO to complete rural grid-based connections.

2. Off-grid technologies could accelerate the delivery of connections in Zambia, but only if the authorities resolve targeted challenges and address gaps in the regulatory framework and collaborate with donors to create structured programs to foster mini-grid development. Donors and the private sector can work together to find sustainable financing schemes, while solar home system providers will need to attain and sustain low end-user prices and resolve staffing issues in remote areas.

[6] World Bank Ease of Doing Business Index, 2016

[7] Total, SuaMoto Energy, Sunnymoney, Vitalite, Suntech, IDsolarsolutions, SolaVillage

INTRODUCTION

This report provides an overview of the Zambian power sector and the main challenges that would need to be resolved for Zambia to achieve its power sector aspirations.

Findings are drawn from over 25 conversations with stakeholders in Zambia and references over 30 existing reports on Zambia's power sector. The in-country USAID mission, the Power Africa Advisors, and stakeholders from the Zambian development partners were also engaged to test the key analyses. In the analysis of **Chapter 4 Challenges to ZESCO's commercial viability along the value chain**, the report draws on publicly available and accessible information, which includes the ERB energy sector report, the 2015 ZESCO integrated report, and the 2016 ZESCO statistical report; however, there are several elements that could not be confirmed without access to ZESCO's management accounts and management.[8] Once USAID SAEP and ZESCO sign the Letter of Collaboration, further insights could be developed.

This report can be used to inform potential areas of intervention for Zambia, ZESCO, cooperating partners, and USAID SAEP to support the delivery of new MW and connections in Zambia.

Its five chapters are as follows:

1. **Power in Zambia** compares the Zambian power market with peer economies and discusses the aspirations that have been set to improve the status quo.

2. **Structure and institutions in the power sector** outlines the institutional design of the sector, including a map of major stakeholders involved in operations, policy-making, long-term planning, regulation, and the acceleration of private-sector participation. The current roles of development partners in Zambia are also discussed.

3. **Long-term supply and demand balance** reviews the potential future demand under a set of scenarios, building on an assessment conducted by the Japan International Cooperation Agency (JICA) in 2010 for the Ministry of Energy, and reviewing the assumptions in this outlook. It then compares the projected demand to the existing pipeline of projects to assess whether Zambia is at risk of facing a supply gap in the short- or long-term.

4. **Challenges to ZESCO's commercial viability along the value chain** moves into the challenges that Zambia's power sector faces, focusing on ZESCO's operational efficiency along the value chain and its commercial viability. Transforming ZESCO into a credit-worthy off-taker and commercially viable entity is the catalyst to driving investment and growth in the sector and economy.

5. **Challenges in delivering electrification** focuses on the state of grid and off-grid electrification, and the successes and challenges that ZESCO and REA face in delivering the connections that underpin electricity demand growth and socioeconomic improvement.

[8] The value chain is defined as electricity generation, transmission, and distribution infrastructure, activities, and services

1 OVERVIEW OF POWER IN ZAMBIA

This chapter presents both the current situation in the Zambian power market and the targets and aspirations Zambia has set to improve the status quo by 2030. The power sector's adequacy is discussed both in terms of its current levels of consumption (kWh per capita) relative to Zambia's peer countries, and the ability of the country's existing generation capacity to meet current demand.

1.1 CONTEXT

Zambia is the 18th largest economy in Africa, with a GDP of USD 20.5 billion in 2016, but its power consumption is below expectations based on comparisons with peer countries.

Only 27 percent of the Zambian population has access to electricity, which leaves eleven million Zambians without access. Average electricity consumption overall is 706 kWh per capita (based on share of total population), which is above the Sub-Saharan Africa (SSA) average of 481 kWh per capita.[9] However, consumption is unequally distributed throughout the country. Households in residential and non-mining commercial areas have an average consumption of only 323 kWh per capita – almost half of the national average (706 kWh).

Zambia facts, 2015

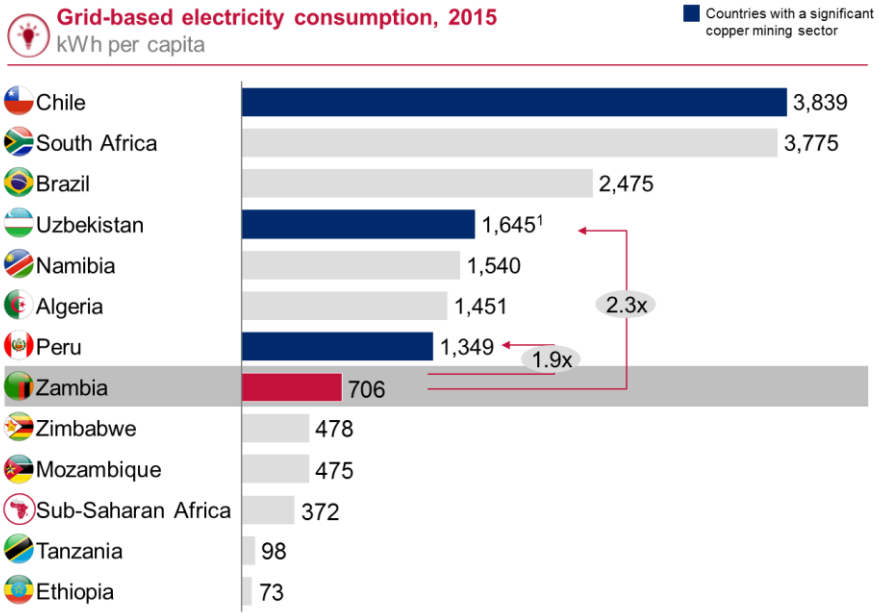
GDP per capita	▪ USD 1,178 / capita
Population	▪ 15.7 million
Poverty levels[1]	▪ Total: 41 percent ▪ Rural: 60 percent ▪ Urban: 13 percent
Access to electricity	▪ Total: 27 percent ▪ Urban: 62 percent ▪ Rural: 4 percent

1 All persons whose per adult equivalent consumption is equal or less than the Extreme Poverty Line (USD 42 / person / month)

SOURCE : WEO 2015, World Bank, LCMS 2015

Zambia's power consumption compares poorly against a set of peer countries that have a comparable range of GDP per capita, a large share of mining power consumption, and / or recognition by key stakeholders that they are an aspirational benchmark (**Exhibit 1**). Zambia's average consumption is only 706 kWh per capita; Peru's per capita consumption is 1.9 times as much, and Uzbekistan's 2.3 times.

EXHIBIT 1: COMPARISON OF ZAMBIA'S GRID-BASED CONSUMPTION PER CAPITA



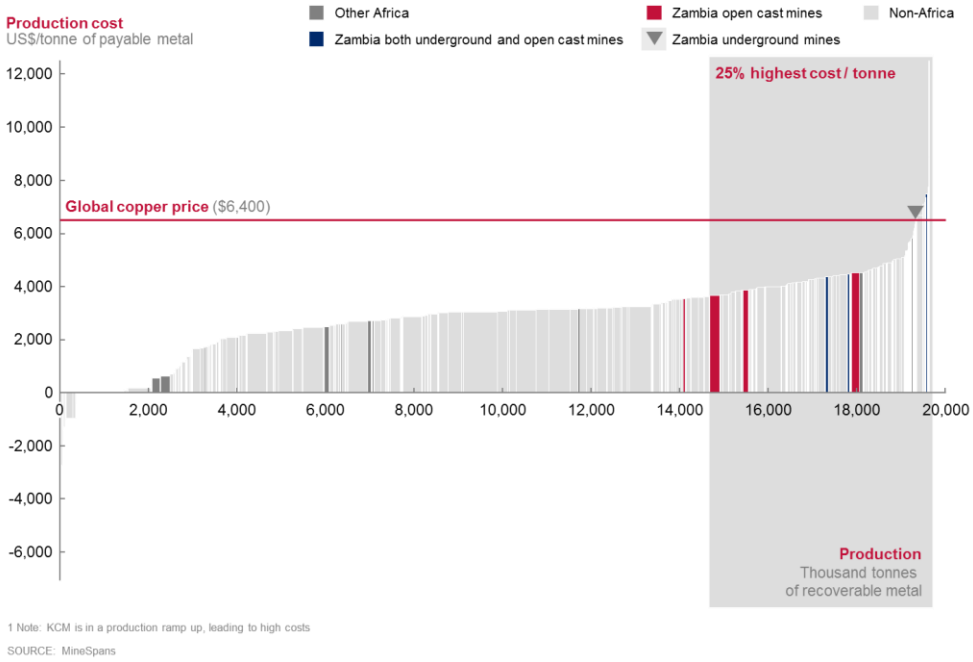
1 As per 2014

SOURCE : World Bank database

[9] Includes population with and without access

The mining sector is a main driver of Zambia's electricity usage, accounting for over half of the country's power consumption. Based on the projects that are currently in the pipeline, and assuming current market prices and no power constraints, the sector could increase its capacity and energy consumption by 40 to 56 percent. The Zambian mines rank high on the global cost curve and are in the top 25 percent in terms of total cost per ton, which is a sign of low cost-competitiveness (as shown in **Exhibit 2**). One of the questions that was surfaced during discussions in Zambia was how much power prices and the availability of reliable power have contributed to the mines production cost. There are a number of factors accounting for the Zambian mines' location on the cost curve in 2016, including high labor costs (partly driven by inflation and the impact of foreign exchange on USD costs), and low ore volumes relative to its cost base (driven by reductions in volume in 2016 in three large mines, potentially exacerbated by power shortages). In addition, the Zambian mining sector is reportedly facing unpaid bills of USD 276 million from an unsettled dispute over a ZESCO tariff hike during the 2015 drought; this was still in arbitration in mid-2017. The high costs and the unsettled dispute may put any potential expansion into question. Energy efficiency efforts could alleviate some of the cost pressure, and is an area that should be investigated further.

EXHIBIT 2: ZAMBIAN MINES ON THE GLOBAL COST CURVE FOR COPPER PRODUCTION



Copper in Zambia

The copper sector accounts for twelve percent of Zambia's GDP. Holding six percent of global copper reserves and fueled by foreign investment, Zambian copper mines saw production grow from 2.8 percent of global supply in 2004 to approximately four percent in 2014.[10] ZESCO's power sources usually service the requirements for copper mining power, which the CEC transmits and distributes. The Copper sector accounts for nearly 55 percent of power consumption in Zambia. In 1997, the sector was privatized in a four-year process that split up the Zambia Consolidated Copper Mines (ZCCM). This created the privately-owned CEC in 1997, founded the government-owned ZCCM Investment Holdings (ZCCM-IH) in early 2000, and resulted in the sale of several mines. ZCCM-IH has a minority stake in three of the four large copper-mining producers in Zambia: Koncola Copper Mines M (Vedanta), Kansanshi (First Quantum), and Mopani (Glencore) along with a twenty percent share in CEC on behalf of the State. These mines, together with the wholly private Barrick Lumwana, account for nearly 80 percent of production in Zambia.

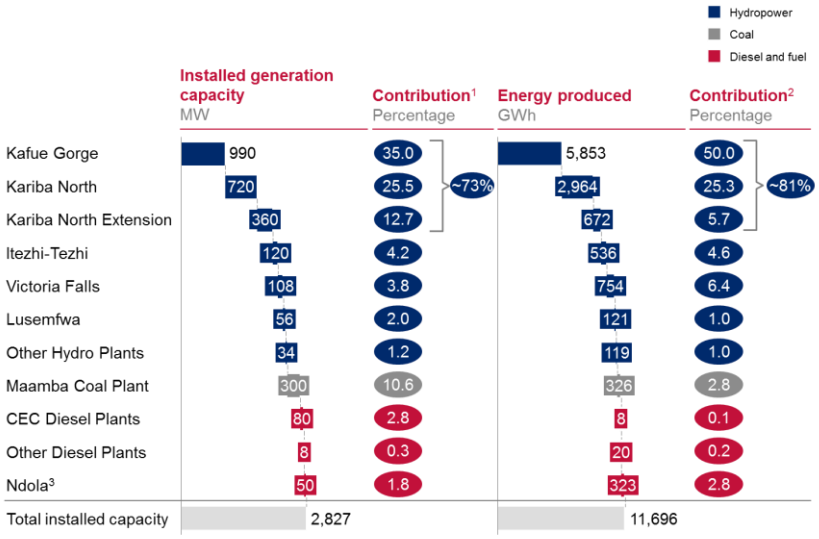
[10] Actual reserves may be higher. As of 2011, only 40 percent of the country was surveyed geologically

1.2 CURRENT SUPPLY AND DEMAND

Zambia is powered by 2,827 MW of installed generation capacity. Under normal circumstances, this supply is sufficient to meet current peak demand of around 2,287 MW and provides an appropriate reserve margin of nearly 23 percent.

As **Exhibit 3** shows, supply is highly concentrated with three assets (Kafue Gorge, Kariba North, and Kariba North Extension) accounting for 81 percent of energy production, which strains the power sector's ability to carry reserves. Zambia relies heavily on hydroelectricity (84 percent of installed capacity), which is concentrated along the Zambezi River and its tributary, the Kafue River.

EXHIBIT 3: INSTALLED GENERATION CAPACITY IN ZAMBIA, 2016



As Zambia has significant water resources, its focus on hydroelectricity is understandable.[11] However, this concentration makes it vulnerable to droughts. Severe drought periods occur regularly; over the past fifteen years prior to the 2015 drought, the country experienced them in 2001 to 2002 and 2004 to 2005, with a moderate drought in 2008 to 2009.

ZESCO's planning and management of water resources during 2014 to 2015 may have exacerbated the impact of low rainfall due to a lag in its ability to replenish the Kariba Dam reservoir. ZESCO added the Kariba North Extension with its two 180 MW turbines and ran these turbines extensively, which exceeded the reduced water allocation for the dam and depleted the water reserves.[12][13][14] When combined with regular power plant outages and system losses, this led to an acute electricity shortage (up to 50 percent of peak demand over the drought period). This forced Zambia to import 785 GWh in 2015 and 2,184 GWh in 2016. Part of the 2015 imports included 165 GWh at 18.35 USD cent/kWh, which ZESCO had to sell to consumers at an average of five USD cent/kWh.[15] These mitigation measures impacted ZESCO's financial viability, which will be further discussed in **Chapter 4 Challenges to ZESCO's commercial viability along the value chain**. To avoid a similar situation in the future, Zambia would need to develop, near-term, up to 600 MW of additional capacity as a reserve for times of drought.

The Zambia national grid, which is critical for getting generation capacity to the demand centers, mainly supports power flows from hydro stations in the South to the Copperbelt province in the North, where the mines are located. The ZESCO grid is

[11] Zambia Development Agency, energy sector profile, 2014, p.3
[12] In 2014
[13] Zambezi River Authority (ZRA) allocation to ZESCO of 10-15 billion cubic meters of water in 2015 to run Kariba Dam reduced by ten-50 percent from previous years
[14] Interviews with local stakeholders and press searches
[15] Freedom to Create, a policy report on the electricity sector in Zambia, 2016, p. 18

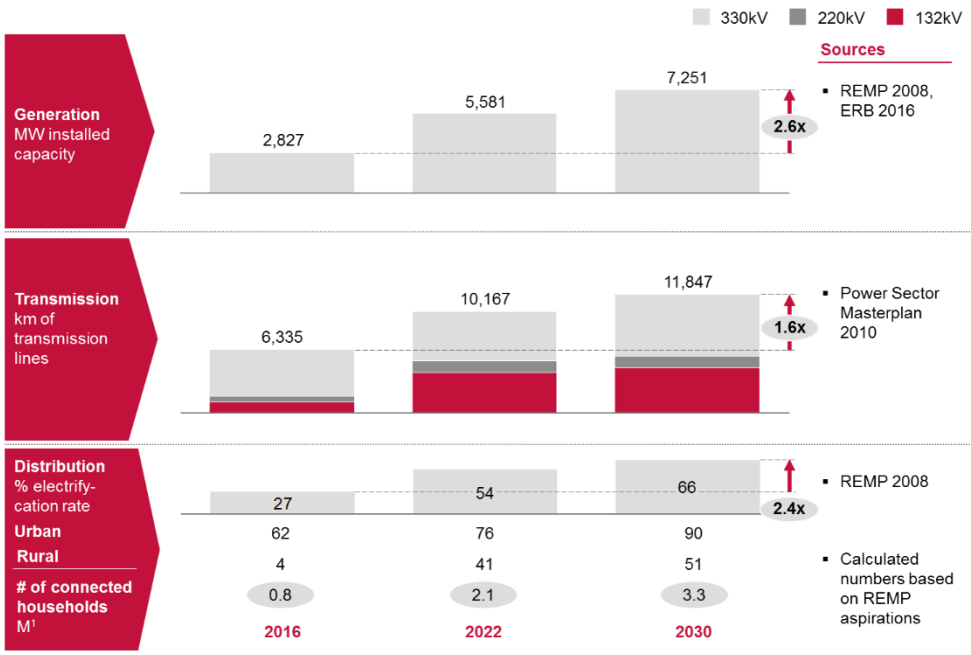
composed of 4,650 km of 330 kilovolt (kV) lines, 385 km of 220 kV lines (serving as interconnectors with the neighboring Democratic Republic of Congo (DRC), Namibia, and Zimbabwe)), 1,054 km of 132 kV lines, and 721 km of 88 kV lines, mainly in the Lusaka area. In addition, the CEC has 246 km of 220 kV lines. Additional investment in the grid will be needed to support Zambia's levels of residential consumption and economic growth, and to integrate renewables. The Ministry of Energy's working figures indicate that currently there is only room for 700 MW of intermittent renewable generation capacity on the grid.

1.3 ASPIRATIONS FOR THE POWER SECTOR

Zambia has made some progress over the last decade in reforming the power sector to unlock growth, drive access, and secure lowest-cost supply during drought periods, but the efforts have not been enough. It has experienced delays in building new plants, had lower-than-needed (i.e., non-cost-reflective) tariffs, and had slow decision-making when trying to deliver new IPP programs. These factors have likely deterred private-sector participants from providing much-needed investment along the value chain and contributed to confusion about how to fund rural household electrification while supporting ZESCO and REA. The absence of an IRP creates further uncertainty around the project pipeline and the government's priorities in the power sector.

The Ministry of Energy and related entities (ERB, OPPPI, REA, ZESCO, Zambia Development Agency (ZDA), etc.) aim to reach ambitious targets for reforming Zambia's power sector by 2030. As illustrated in **Exhibit 4,** these include increasing installed generation capacity 2.6-fold (from 2.8 to 7.2 GW), extending the transmission grid by 5,512 km (to grow 1.9-fold), and achieving a 66 percent electrification rate (2.4 times the current level). To enable all of these, Zambia also aspires to ensure cost-reflective tariffs and the commercial viability of ZESCO. Although these targets exist in separate policy documents such as the REMP (2008) and the Ministry of Energy's annual presentations, they are generally consistent across those documents.

EXHIBIT 4: ASPIRATIONS IN THE ZAMBIAN POWER SECTOR, 2016 TO 2030



1 Assuming a total population of 16.2 million in 2015, growing at a rate of 3% per annum, at an average of 5 people per home
SOURCE: Energy Sector Report 2016, REMP 2008-2030, WorldBank GTF, World Energy Outlook 2016

These aspirational targets represent a significant qualitative shift compared to past performance and the status quo (see **Exhibit 5**):

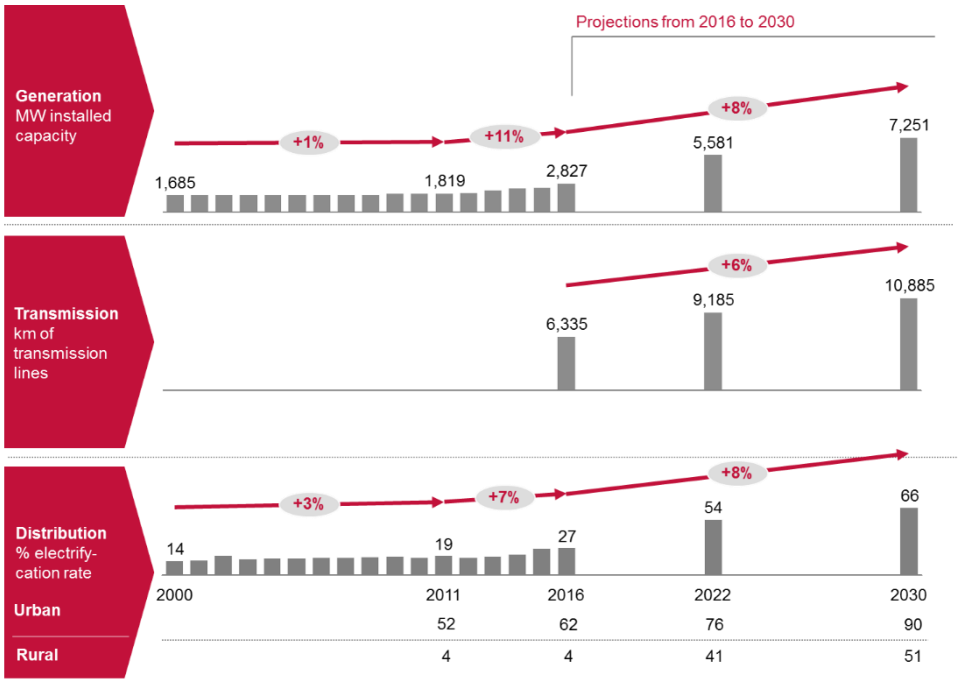
- **Generation**. Future growth targets are in line with the sector's development over the last five years. In addition (see **Chapter 3 Long-term supply and demand balance)** there is a sufficiently large pipeline of power projects in the

planned timeframe. However, because these include intermittent and non-intermittent / dispatchable power projects, Zambia would still possibly face a supply-demand gap in the short- and medium-term.

- **Transmission.** It is hard to comment on the targets without data on the grid's historical development, but it is clear that the grid will need to be extended and strengthened to accommodate additional generation capacity, especially when integrating intermittent renewable energy. Estimates indicate that the current grid cannot support more than 700 MW of intermittent capacity.[16] Of that, 550 MW will probably be taken up by Scaling Solar I and II and the Global Energy Transfer Feed-in Tariff (GET FiT) program.[17]

- **Distribution and electrification**. Total electrification growth is in line with Zambia's historical performance over the last five years. However, the aspiration relies primarily on connection growth in rural areas, which will be a much more challenging and expensive undertaking. In addition to the economic viability issues mentioned above, there is also a timing concern; it took Zambia fifteen years to get from two percent to four percent rural electrification (see **Chapter 5 Challenges in delivering electrification**).

EXHIBIT 5: ASPIRATIONS IN THE ZAMBIAN POWER SECTOR RELATIVE TO PAST PERFORMANCE



SOURCE: Energy Sector Report 2016, REMP 2008-2030, WorldBank GTF, World Energy Outlook 2016

While historical performance has been low for generation and distribution – only one percent p.a. and three percent p.a. respectively from 2000 to 2010 – performance in recent years has been better: eleven percent and seven percent. These higher growth rates will need to be maintained in the coming years if Zambia is to achieve its aspirational targets across the electricity value chain.

To contribute towards how the Zambian Government might think about reaching its targets, the USAID SAEP is developing a geospatial model that identifies the least-cost technology per household (among grid, solar mini-grid, hydro mini-grid and SHS). This model will provide a directional view on the mix of technologies at lowest cost to roll out electrification, as well as a total cost estimate for this technology mix.

[16] According to research by the Ministry of Energy

[17] IDC refers to a total of 600 MW while the IFC website refers to a total of 500 MW. Based on latest in-country discussions, this would break down as follows: 80-100 MW for Scaling Solar I and >180 MW for Scaling Solar II. It is possible that there will also be a third round. GET FiT is currently preparing to tender 100MW of Solar PV through an auction

2 STRUCTURE AND INSTITUTIONS IN THE POWER SECTOR

This chapter outlines the power sector's current structure and institutions. It also explains its governance, discusses the policy-making and regulatory environment, and describes the market model as well as public and/or private sector participation. It ends with a review of donors' current role in the Zambian power sector and the potential gaps that USAID SAEP could address.

2.1 GOVERNANCE OF THE POWER SECTOR

The Ministry of Energy drives policymaking and target setting in Zambia's power sector. It develops the long-term sector plan, the renewable energy policy, the electrification strategy, and energy efficiency / demand-side management policies and regulations. As previously mentioned, Zambia does not yet have an IRP, but the Ministry has expressed its intent to develop a planning process that will be linked to the IPP procurement process.[18] REA is in charge of implementing the Ministry's policy decisions in rural areas. REA strategy is based on the REMP (2008) that targets electrification of 1,217 Rural Growth Centers (RGCs) throughout the country primarily through extension of the national grid.

Although the current legal framework governing the Zambian power sector is comprehensive, it is also more than ten years old. As a result, it focuses heavily on grid-based operations without fully accounting for the possibilities and requirements of current technology and trends (e.g., off-grid, mini-grids, solar). In just one example, the same regulations and requirements apply to mini-grids and utility-size power plants (e.g., for land acquisition or environmental assessments).

The following documents contain the legal and regulatory framework of Zambia's power sector.

- **Electricity Act of 1995 (amended in 2003):** This act formulates the principles of generation, transmission, and distribution of electricity in Zambia. It supports the liberalization of the electricity sector by formally opening all three segments to private sector participation and outlines the administrative structure of the sector.
- **Energy Regulation Act of 1995 (amended in 2003):** This act formulates the role of the ERB and defines its functions and powers.
- **Rural Electrification Act of 2003:** This act mandates that REA will oversee and implement the rural electrification program. REA subsequently developed a detailed REMP (2008) aimed at improving the very low rural electrification rate in Zambia and provided a trajectory for electrification for the period 2008 to 2030. The REMP (2008) highlighted three main electrification methods: extension of the national grid, mini-grids, and solar home systems.
- **The Zambia Grid Code of 2006:** The Zambia Grid Code provides IPPs with open and nondiscriminatory access to the transmission system.

To improve the environment for the private sector in grid and off-grid markets, the Government of Zambia is reviewing three of these bills (Electricity Act, Energy Regulation Act and Rural Electrification Act). The timeline is unclear, but the review should be concluded in 2018.

To complete and update the regulatory environment and improve private sector participation in the power sector, Zambia will need to consider three key additions to the regulatory environment:

1. **A comprehensive regulatory framework for mini-grid players.** Mini-grid developers require a set of clear policies and guidelines to ensure a level playing field and create planning certainty, including:

[18] Interview with Ministry of Energy - Department of Energy

- **Adjustments to license requirements based on location or amount of electricity.** Mini-grid (60 kW to ten MW) licensees are currently required to obtain a similar set of licenses to those for large IPPs. For smaller providers this can create a major impediment to scale-up.[19]

- **Additional issues that need to be addressed.** These include a mini-grid tariff vs. the national tariff, standards for mini-grids, implications of a grid extension on the existing mini-grids, and concession areas.[20]

2. **An adaptation of the grid code to accommodate renewable energy**. Integrating intermittent energy projects into the grid poses challenges that the grid code does not presently consider. Zambia needs to assess the grid's ability to incorporate intermittent power and identify the required enhancements for its operations (e.g., the current power supply forecast is set a day ahead rather than in real-time).[21]

3. **The launch of the Renewable Energy Feed-in-Tariff (REFiT) policy.** Kreditanstalt für Wiederaufbau's (KfW's) GET FiT Zambia will assist the Government of Zambia in implementing its REFiT strategy to contract 200 MW of renewable energy onto the grid in the next three years:
   - The program targets the development of small- to medium-scale IPP projects (between one to twenty MW).
   - Round One will be for up to 100 MW of solar PV capacity (estimated tender date January 2018). Subsequent tenders will call for other technologies, including hydro, biomass, and geothermal.[22]

2.2 REGULATION OF THE POWER SECTOR

The ERB is the independent energy regulatory authority in Zambia. Founded in 1997, the ERB issues licenses, regulates the operations and pricing of the electricity sector, establishes and monitors the application of the Zambia Grid Code, and designs standards around the quality, safety, and reliability of the energy supply. The ERB's mandates and powers emanate from the Energy Regulation Act of 1995 (amended in 2003).

The Minister of Energy appoints the Board members of the ERB, which carry out the ERB's functions.[23] The chairperson and vice chairperson are elected from among the members. All Board members operate part-time. The current Board consists of seven members. Technical staff support the Board members across a variety of functions.

One of the ERB's responsibilities is to set electricity tariffs, which it reviews annually. Very little information on the components that inform the tariff build-up is publicly available, other than that the ERB uses a Cost Plus or Revenue Requirement methodology that includes cost of supply (i.e., generation, transmission, distribution, and retail costs, operating and maintenance costs, and depreciation cost) and a rate of return on capital. As **Chapter 4 Challenges to ZESCO's commercial viability along the value chain** details, Zambia's current average revenue per energy unit billed is 7.1 USD cent/kWh and is not considered to be cost-reflective. The ERB has collaborated with the AfDB to conduct a cost-of-service study, which aims to reduce subsidies, reform tariffs, and ensure that tariffs become cost-reflective. The results of this study were due at the end of 2017.

The ERB also introduced and adopted an incentive-based regulatory framework in 2007.[24] The framework bases any tariff awarded to ZESCO on both the tariff ERB calculates and on ZESCO's performance across a set of eight of ERB's KPIs (i.e., metering customers, cash management, staff productivity, quality of service, system losses, power generation, safety, and customer complaints).[25] The current framework, in **Exhibit 6,** was co-signed by ZESCO and the ERB and runs from 2017 to 2019. The ERB uses the average KPI score for the year preceding the tariff change application to determine what percentage of the calculated tariff ZESCO receives. For 2017, the ERB reportedly calculated a tariff base of twelve USD cent/kWh. ZESCO's KPI performance for 2016 was 65 percent, meaning they were entitled to 75 percent of the ERB-calculated tariff base (i.e., nine

[19] Interview with SIDA Country Manager on Beyond the Grid challenges
[20] ENEA Developing mini-grid in Zambia - 2016
[21] IRENA Renewable Readiness Report – 2013
[22] GET FiT Zambia, 2017
[23] http://www.erb.org.zm
[24] ERB Press statement, 2009
[25] ERB Energy sector report, 2016, p. 52

USD cent/kWh). As a result, a 50 percent tariff increase from six to nine USD cent/kWh was approved for May 2017, with an additional 25 percent increase in September 2017. [26]

EXHIBIT 6: ERB'S INCENTIVE-BASED FRAMEWORK FOR ZESCO TARIFF REVIEWS

ZESCO score on ERB KPIs[1]	Tariff increase awarded by ERB[2]
75% and above	One hundred percent (100%) of the ERB determined fee
Between 50% and 75%	Seventy five percent (75%) of the ERB determined fee
Between 25% and 50%	Fifty percent (50%) of the ERB determined fee
Less than 25%	Twenty five percent (25%) of the ERB determined fee

ZESCO tariff = ERB determined tariff multiplied by overall KPI score

1Percentage attainment against KPIs
2 Increase awarded as a share of the requested determination

SOURCE: ERB

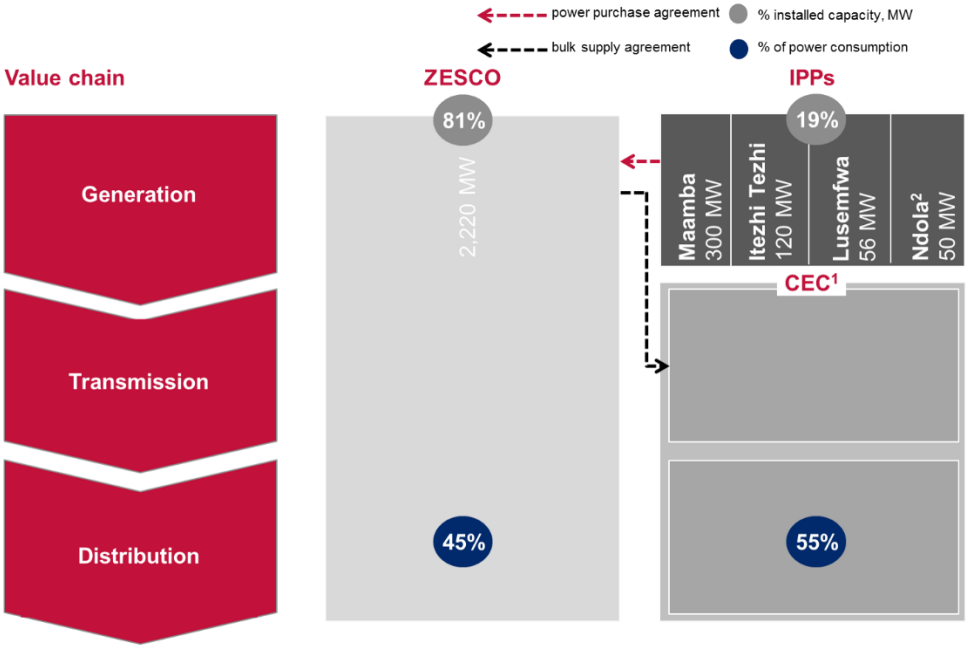
2.3 MARKET STRUCTURE

Zambia's electricity sector is set up as a de facto, single-buyer market, as illustrated in **Exhibit 7**. The vertically integrated utility ZESCO functions as the single buyer and the system operator, and controls 81 percent of the country's installed capacity.[27] In August 2015, the Government of Zambia transferred its shareholding in 34 state-owned enterprises, including ZESCO and all its subsidiaries and investee companies, to the IDC. At the end of 2016, ZESCO was the largest company in the IDC portfolio, representing about 65 percent of the portfolio's value with assets of approximately USD 2.8 billion.[28]

The second main contributor to the daily operation of the Zambian power market is the CEC, which accounts for over half of the national power consumption. The CEC services mining companies in the Copperbelt province, and purchases electricity from ZESCO via a Bulk Supply Agreement (BSA). The CEC was established during the privatization of the ZCCM and its power division in 1997.[29]

[26] ERB Statistics bulletin, 2016, p. 14
[27] 2016 ERB report
[28] ZESCO Technical Committee TOR, 2017, p. 2
[29] Press search and CEC website, 2017

EXHIBIT 7: ZAMBIA'S SINGLE BUYER MARKET MODEL



1 CEC has 80 MW generation capacity
2 Excludes 55 MW plant that came online in March 2017
SOURCE: ERB Sector Report 2016, FTC Policy Report 2016 & ZESCO integrated report 2015

Four institutions focus on policy-making and implementation with respect to private sector participation:

1. **The IDC** is an investment and holding company, wholly owned by the Government of Zambia. Since 2015, it has held shareholder responsibility for all state-owned enterprises. The IDC's core mandates are to stimulate industrial development and growth in Zambia, and to maximize shareholder value for the assets under its management. The mandate also ensures that all state-owned enterprises are ultimately privatized through their listing on the Lusaka Stock Exchange.

2. **The Ministry of Energy** is responsible for framing policies and providing guidance through the Department of Energy. As a unit of the Ministry, the **OPPPI** promotes the development of greenfield power projects through IPPs. It also coordinates these IPPs' engagement with other relevant actors (e.g., the ZDA, the Ministry of Energy, and ZESCO) throughout the IPP development process (from proof of concept to financial close).[30] As part of these efforts, it leads the processes that manage solicited and unsolicited private-sector project requests.

3. **The ZDA** awards fiscal and non-fiscal incentives after the OPPPI has reviewed and accepted the feasibility study. ZDA decisions are discretionary and based on the facts that IPPs present to justify receiving certain incentives

4. **The PPP unit** is a stand-alone statutory body that reports directly to the State House. It structures and negotiates PPPs in all sectors, and is responsible for the manuals and guidelines for the effective procurement and implementation of PPP projects.

Zambia has an extensive process to encourage private-sector participation in the power sector, which OPPPI leads.[31] **Exhibit 8** illustrates the processes for both tendered (solicited) and unsolicited requests:

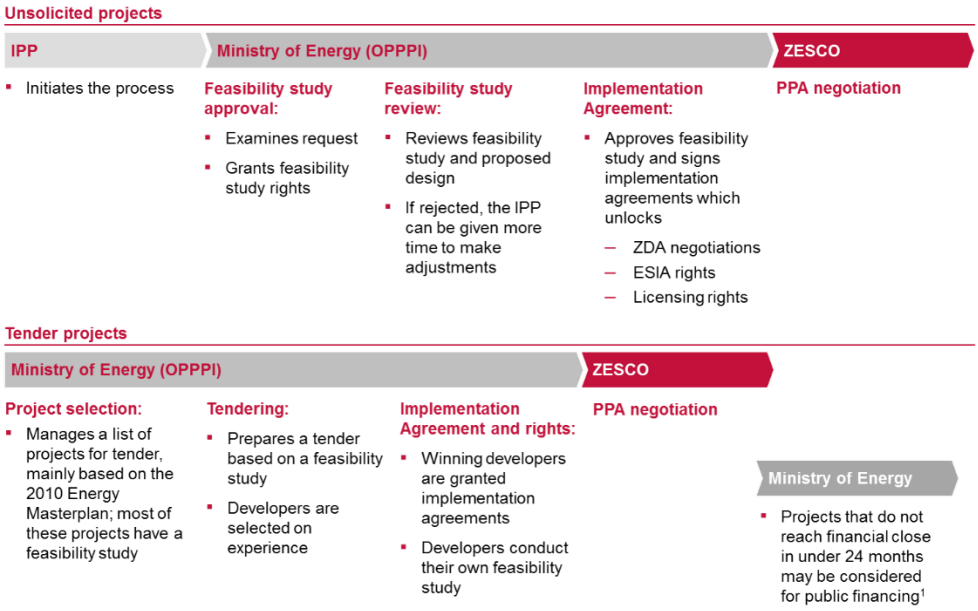
- **Tendered projects**: The OPPPI manages the tender process, which includes developing the Request for Proposals and awarding the tender. Developers that win tenders are entitled to an Implementation Agreement (IA) with OPPPI. The IA allows developers to obtain the required licenses, conduct an environmental study, and receive financial incentives from the ZDA. If they have all the requisite documents, they can then enter into PPA negotiations with ZESCO.

[30] OPPPI manager interview, Oct 2017
[31] OPPPI Manager interview, Oct 2017

There are currently six tendered hydro projects that have received IAs. An exception to this process was deployed for the Scaling Solar program in Zambia, which the IDC and IFC established to explore the development of two to four large-scale solar projects through a competitive auction.

- **Unsolicited projects**: Developers interested in building a power plant in Zambia outside a tendered process must contact the OPPPI to receive approval to conduct a feasibility study. Projects are granted this right following a review of the project pipeline for overlap, and a check for alignment with ZESCO's directives (e.g., maximum capacity of the grid for a specific technology). The OPPPI then reviews the feasibility studies and provides implementation agreements (IA) for projects with a sound design and clear plan to reach financial close. A developer that receives an IA then follows the same process to start a PPA negotiation with ZESCO, as outlined below. There are currently two unsolicited hydro projects that have received IAs.[32]

EXHIBIT 8: PROCESS FOR PRIVATE SECTOR ENTRY INTO THE POWER SECTOR



1 For example, Kafue Gorge Lower was tendered and then taken on as a publically financed project (i.e. 85% financed by borrowing from the ExIM Bank of China, and 15% from direct government contribution)

SOURCE: OPPPI interviews

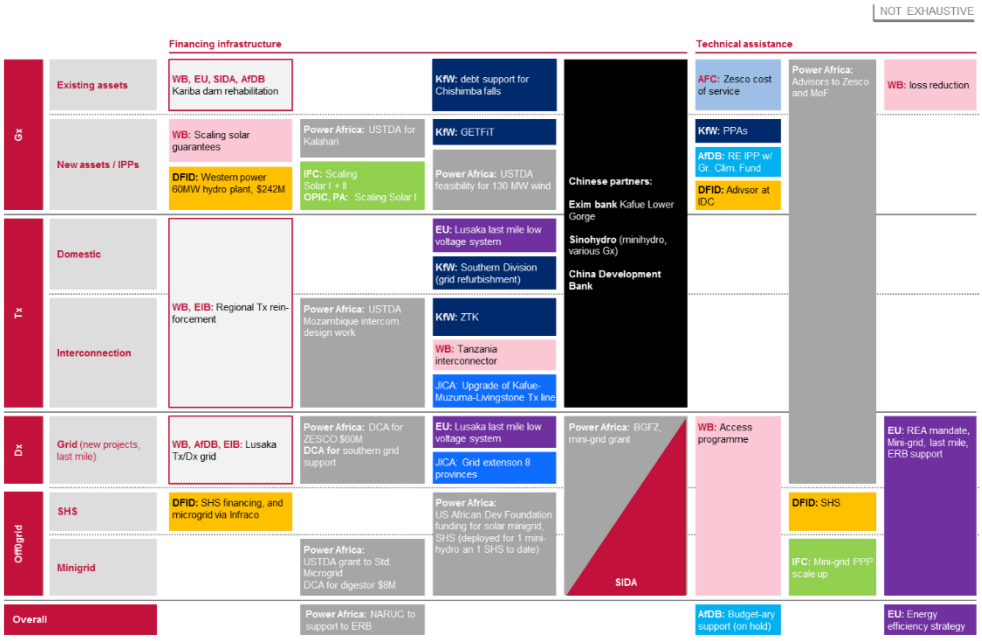
2.4 KEY EFFORTS AMONG DEVELOPMENT PARTNERS

Development partners have historically played a critical role in facilitating power sector reforms in Zambia. As shown in **Exhibit 9** many continue to contribute to the operations and expansion of the sector. The main development partners include AfDB, Chinese Development Bank, Department for International Development (DFID), European Union (EU), European Investment Bank, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), IFC, JICA, KfW, SIDA, USAID, and World Bank.

Development partner activities include providing financing for infrastructure developments in the sector, technical assistance across generation, transmission, distribution, and off-grid (e.g., embedded advisors in institutions such as ZESCO and the Ministry of Finance, SIDA scaling up mini-grids and the solar homes systems sector; and activities to facilitate private sector participation).

[32] EMCO (340 MW) and Kundabwika Falls (151 MW)

EXHIBIT 9: DEVELOPMENT PARTNER ACTIVITIES IN ZAMBIA



SOURCE: Development partner engagements

The mapping in the exhibit highlights the fact that the sector is well supported by donors across the value chain (generation, transmission, and distribution, including off-grid). Due to broad-based support, the focus is on obtaining buy-in from the Ministry of Energy and relevant stakeholders, and executing existing recommendations. The high level of coverage means that additional support needs to be highly targeted, and focused on opportunities that are not already being addressed or need strengthening.

A coordination working group of the development partner community (the Cooperating Partners' Group) was set up and convenes every two months to share information and resolve gaps or overlaps in current activities. The chair rotates among donors and is currently held by the EU.

3 LONG-TERM SUPPLY AND DEMAND BALANCE

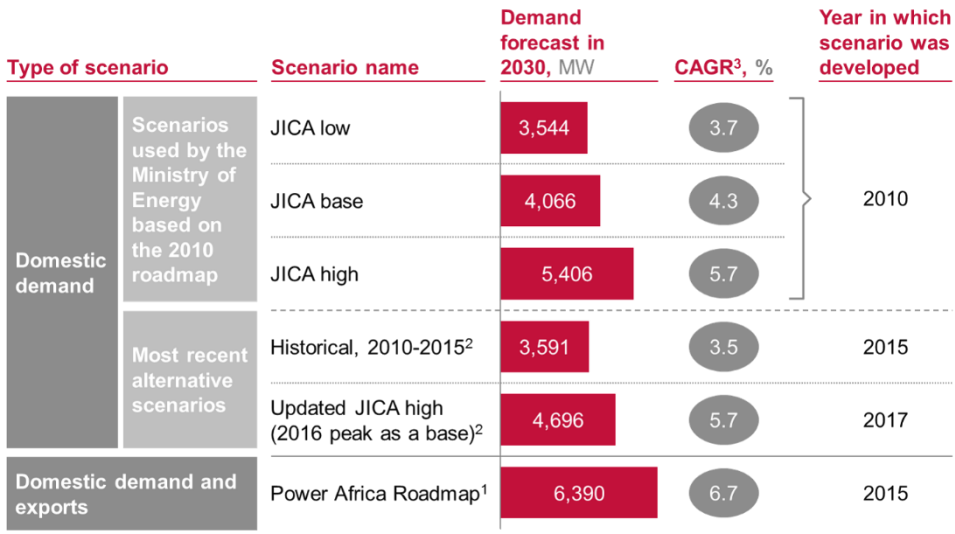
This chapter provides a perspective on Zambia's supply and demand balances, identifies potential short- or long-term gaps, and explores several issues Zambia may want to explore. The analysis revealed a potential short-term demand-supply gap (2017 to 2022), which would range from 90 MW to 600 MW at different points in time, and could peak at about 1,000 MW in the event of a severe drought. In the longer-term (2022 to 2030), Zambia has a sufficiently large pipeline of power projects to meet its domestic capacity requirements up to 2029 (based on the historical growth trajectory). However, in the high-growth scenario it faces a widening gap that reaches 1.4 GW in 2029 (at peak load and excluding intermittent energy sources such as solar).[33]

Given that no IRP exists that provides a view on the planned sequence of projects, the methodology used here works off the current status of projects in the OPPPI pipeline along the project lifecycle (i.e. from proof of concept to operations. A view is provided on how long it would take to complete these projects based on the type of technology and average timelines in other African markets. This provides a 'timeline risk-adjusted' estimate of the MW that could come online by 2030.

3.1 DEMAND FORECAST

To estimate future demand and required capacity, different demand projections were compared in two scenarios with different growth rates and then supplemented with a reserve margin. These scenarios used the JICA methodology as a starting point, and validated it against historical growth rates. The scenarios and estimate used in the new analysis are shown for domestic demand under alternative scenarios in **Exhibit 10** – the Historical 2010-2015 scenario the Updated JICA High scenario.

EXHIBIT 10: POTENTIAL DEMAND BY 2030



1 Power Africa roadmap considers internal demand and allowance for exports
2 A reserve margin needs to be added to these two scenarios to translate demand forecasts into capacity requirements
3 Compounded Annual Growth Rate
SOURCE : Power Sector Masterplan 2010, Power Africa roadmap 2016

JICA's original model forecast three types of domestic demand (industrial, retail, and commercial, with some sub-types) under three scenarios (low, base, and high) until 2030.

- **Mining demand** was estimated using available information on the upcoming pipeline of new mining projects and capacity expansions, leading to an implied five percent per annum growth in all three scenarios.

[33] An intermittent energy source is any source of energy that is not continuously available for conversion into electricity and outside direct control because the used primary energy cannot be stored (e.g., typically wind or solar power). Intermittent energy sources may be predictable but cannot be dispatched to meet the demand of an electric power system

- **Other industrial demand** was projected via a regression of power consumption to GDP growth from 2000 to 2007. The assumed GDP growth per annum in the three scenarios is: five percent (low); six percent (base); and seven percent (high).

- **Retail and commercial demand**, including current as well as new connections, was estimated through a regression of 2000 to 2010 actuals data, which determined the effect of increased household income and increased GDP per capita on energy demand. Based on the correlations and historical growth rates, the electrification rates per annum were forecast to be: 3.5 percent (low); four percent (base); and six percent (high). To determine the power-consumption growth rate, population growth was assumed to be 2.3 percent per annum.

The resulting electricity demand growth projections per annum for the original JICA scenarios are: 3.7 percent (low); 4.3 percent (base); and 5.7 percent (high). The Power Africa roadmap includes the potential for exports, thereby raising the demand forecast.

The analysis conducted for this assessment looked at two further scenarios for domestic demand: a historical demand projection scenario, and an update of JICA's high scenario for this assessment. The **historical demand projection scenario** extrapolates Zambia's demand growth between 2010 and 2015. Zambia's actual demand growth between 2010 and 2016 was close to the JICA's original low and base scenarios. The **Updated JICA high scenario** applies the growth rates from the original JICA high scenario to Zambia's latest peak demand from 2016.

To determine the required capacity to meet this projected peak demand, a 30 percent buffer was added. This buffer was determined by looking at the historical impact of adverse hydrological conditions on hydro plants. This implies required capacity by 2030 of 4,594 MW under the historical growth scenario and 6,007 MW under the updated JICA high scenario.

Demand is also expected to evolve in step-changes along the way (e.g., as new mining projects come on line) rather than as a smooth trajectory, which will put additional pressure on the short-term supply and demand balance; this is discussed in **Section 3.3.1 Short-term balance (2017 to 2022)**.

3.2 SUPPLY PIPELINE

The 2010 Power Sector Masterplan (developed for the Ministry of Energy) identified 4,300 MW that could be operational by 2030. The current OPPPI pipeline revised the 2010 Masterplan's project pipeline upwards to include recent project proposals, which significantly increased after the 2015-2016 drought.[34] As a result, the total pipeline considered in the report had nearly 6,700 MW additional capacity by 2030. The OPPPI project pipeline excludes large cross-border projects and references domestic capacity.

To determine how much of this pipeline could be expected to come on line between 2017 and 2030, a set of sub-Saharan African Power Infrastructure development benchmarks were used to sense-check the lead times of these projects, which vary based on technology (e.g., solar, hydro, and wind) and project stage. The stage indicates how far along in the process the technology is; for example, a hydro dam at the first stage could take fifteen years to come on line.

Based on Power Africa's Tracking Tool, the stages from conceptual to financial close, are: stage one, including conception, pre-feasibility, and / or feasibility; stage two: which involves development and / or project structuring; stage three, which is financing; and stage four, which is financial close.

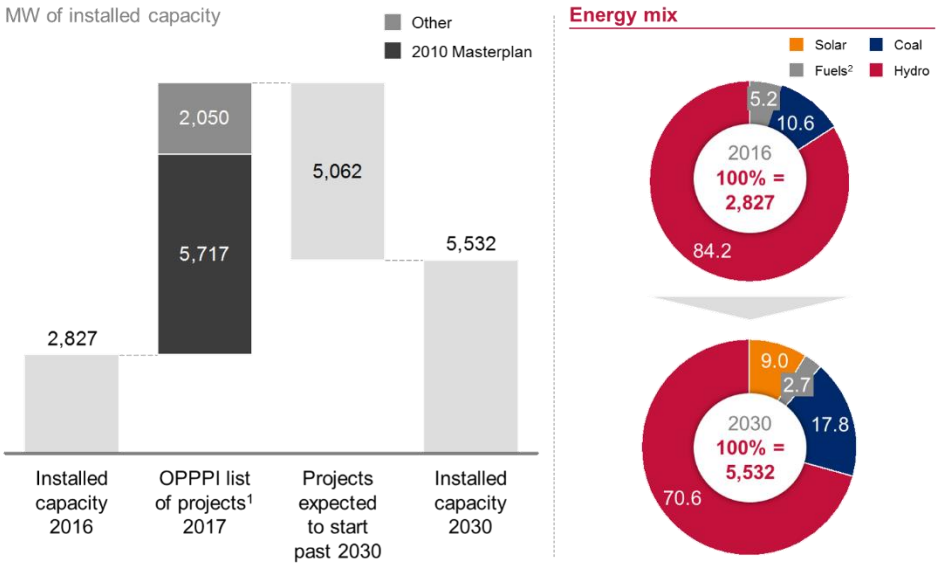
As of October 2017, there were six Stage Three (financing) projects in the OPPPI's pipeline, with a total capacity of 1,027 MW. In addition, two hydro projects (Musonda Falls ten MW and Kafue Gorge Lower (KGL) 750 MW) were under construction.

A lead-time adjusted view of the OPPPI pipeline indicates that 2,705 MW could realistically come on line by 2030, and that any more capacity would require significant acceleration of project timelines. This would put Zambia's installed capacity at 5,532 MW in 2030 (2,705 MW in addition to the current 2,827 MW), with a generation mix of 70 percent hydro, 21 percent thermal (coal), and nine percent solar (see **Exhibit 11**). This total is 1,168 MW less than the projected total for 2030 (6,700 MW). While

[34] The OPPPI pipeline was taken as the base project pipeline for this report, given that projects in the OPPPI pipeline encompass projects in the power sector masterplan. Additionally, the OPPPI tracks the status of the projects' development.

this analysis is based on the existing projects, the reality is that if Scaling Solar is successful in Zambia, and if solar prices continue to drop, there will be a strong case to bring a greater share of solar generation on line.

EXHIBIT 11: POTENTIAL FUTURE SUPPLY BY 2030 (PROJECT PIPELINE)



1 Unsolicited projects with feasibility study rights and/or tendered projects with signed implementation agreements
2 Including HFOs
SOURCE : OPPPI pipeline, Power Masterplan 2010

Any delays past the expected lead times for projects in the OPPPI list would further reduce the potential number of additional MWs available by 2030, and potentially endanger the long-term supply / demand balance. Seven cross-border projects in the pipeline could deliver an additional 4,300 MW; however, these are all currently Stage One (conception / feasibility) and have been adjusted to projects that would come on line post 2030. [35] In addition, a number of these projects require political commitments and / or developments, such as a river authority to be formed (e.g., the large 1,100 MW Luapula River dams).

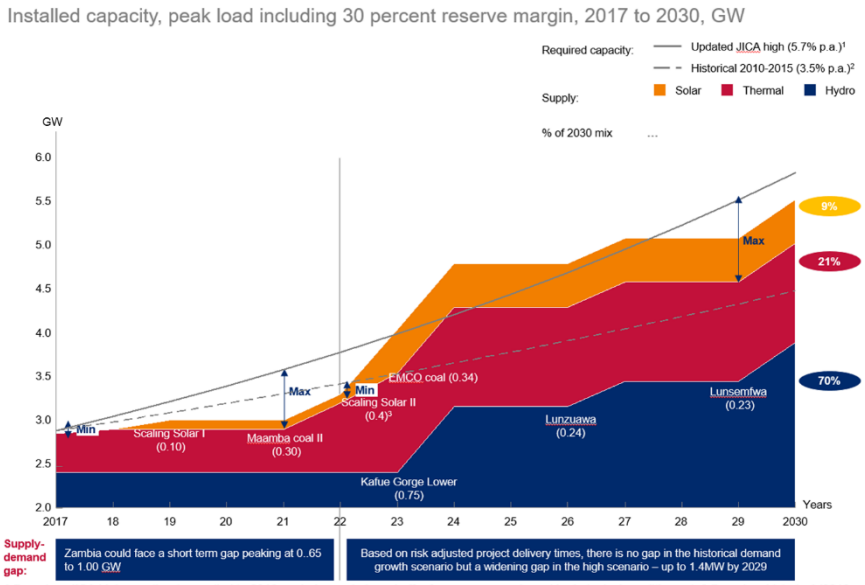
The OPPPI project list also highlights ongoing investigations of new technologies such as geothermal and wind. These were not included in the pipeline analyses because they are at fairly early stages. However, if they succeed, the technologies could also provide additional capacity.

3.3 DEMAND AND SUPPLY BALANCE

Analysis shows that although Zambia could build sufficient new generation capacity to meet the growing demand over the long term, it may need to address a short-term shortfall (**Exhibit 12**).

[35] Mambilim Falls I, II & V; Mumbotuta Falls; Batoka Gorge; Devil's Gorge; Mpata Gorge

EXHIBIT 12: SUPPLY AND DEMAND BALANCE FOR 2017 TO 2022 AND 2022 TO 2030



1 Based on JICA high growth rate, applied to 2016 peak demand plus a buffer for reserve margin and hydrological conditions | 2 Based on historical (2010-2015) growth rates plus a buffer for reserve margin and hydrological conditions | 3 IDC refers to a total of 600MW while IFC website refers to a total of 500MW. Based on latest in-country discussions, this would break down as follows: 80-100MW for Scaling Solar I, >180 MW for Scaling Solar II. It is possible that there will also be a third round

SOURCE :OPPPI pipeline, Power Masterplan 2010

3.3.1 SHORT-TERM BALANCE (2017 TO 2022)

The lead-time adjusted pipeline illustrated in **Exhibit 12** indicates that Zambia's installed capacity by 2022 could be nearly 3,282 MW, 455 MW more than the current 2,827 MW.[36] However, the demand forecast for 2022 indicates that Zambia may need up to 3,500 MW capacity (this number includes a reserve margin and a buffer for drought impact). A capacity shortfall of 90 MW to 600 MW is possible from 2018 to 2022, even if the Maamba Coal II expansion project (300 MW) comes on line before 2023.[37] The gap could be even larger if expected demand grows through step-changes (e.g., as new mining projects are completed) instead of gradually (as assumed in the model).

Zambia will need to consider short-term mitigation measures, including:

- **Demand side management** reduces peak load by shifting consumption patterns and improves energy efficiency. Programs are designed to encourage consumers to alter their level and pattern of electricity usage during on- and off-peak hours could include financial measures such as time-of-use tariffs and incentives to prioritize power use when it is abundant and cheap.
- **Improved hydropower management** can optimize the recharge times based on weather patterns and demand needs, and enhance reservoirs. These enhancements could also affect electricity imports.
- **Importing electricity** through the SAPP to meet demand during times when the buffer is insufficient (e.g., severe drought). This situation should be carefully considered because of the potential differences in import costs and ZESCO's tariffs; improvements in water management and planning will be essential inputs to these situations.

There may also be the potential to fast track certain projects in the pipeline. More importantly, Zambia needs to ensure that the existing timelines on projects are met (e.g., avoid delays in approving critical licensing) and that projects are completed successfully.

[36] ERB Energy sector report, 2016

[37] The Maamba Coal is an extension to the existing site and is currently in pre-construction stage with a wide range of lead-time adjustments (i.e., two to five years until it is operational). The current lead-time adjusted pipeline uses the high end of this range.

3.3.2 LONG-TERM BALANCE (2022 TO 2030)

In the long-term, the lead-time adjusted pipeline indicates that Zambia's installed capacity could be nearly 5,532 MW by 2030 (2,705 MW in addition to the current 2,827 MW). Over the same period, the demand forecast indicates that Zambia's capacity needs may reach 4,594 to 6,007 MW.[38] This assumes, however, that some of the well-known projects, e.g., the Kafue Gorge Lower (750 MW), Scaling Solar II (300-400 MW), and EMCO Coal (340 MW) are completed by 2026.[39]

In addition to this pipeline, research indicates that Zambia has ample unexploited resources that could be developed and enable its aspirations to be a net power exporter. However, the challenge of balancing the development of intermittent capacity with baseload power will remain. Such resources include:

- **Hydro:** Zambia has significant water resources with 6,000 MW potential capacity.[40] The lead-time adjusted supply pipeline indicates that Zambia could install nearly twenty percent of this capacity by 2030.[41]
- **Coal:** Zambia's coal deposits are estimated between 30 million and 100 million tons.[42] Zambia has two coal mines: Maamba Coal and Collum Coal (re-opened in 2015), both in southern province.[43]
- **Solar:** Zambia has an average solar insolation of 5.5 kWh/m^2/day, with approximately 3,000 hours of sunshine annually, providing good potential for solar thermal and photovoltaic applications.[44]
- **Biomass:** The biomass potential is estimated at 2.15 million tons, or 498 MW.
- **Wind:** Three wind projects are currently being explored by developers Access, Globaleq, and Mainstream Energy
- **Geothermal:** Kalahari Geo Energy Ltd is currently investigating geothermal potential in the Kafue area where many hot springs exist such (e.g., Bwanda, Gwisho, and Namulula (Bwengwa River Geothermal Area)). Preliminary results from the investigations support a geologic setting conducive to hosting a geothermal system.

Zambia will also need to create the enabling environment that ensures that the entire pipeline is delivered. Such an environment will equip developers to make progress on their projects (e.g., avoiding time delays and uncertainty as much as possible). Zambia will also need to address ZESCO's commercial viability, allow the utility to finance its own projects, and strengthen it as a reliable off-taker for IPPs as discussed in the next chapter.

[38] Peak demand plus reserve margin and a buffer for drought impacts

[39] IDC refers to a total of 600 MW, while the IFC website refers to a total of 500 MW. Based on the latest in-country discussions, this would break down as follows: 80-100 MW for Scaling Solar I and >180 MW for Scaling Solar II. It is possible that there will also be a third round.

[40] *Freedom to Create*, a policy report on the electricity sector in Zambia, 2016, Zambia Development Agency, energy sector profile, 2014, p.3

[41] The 20% of 6,000 MW potential capacity is calculated to include Kafue Gorge (750 MW), Lnzuawa (240 MW) and Lunsemfwa (230 MW), which totals 1,220 MW

[42] *Freedom to Create*, a policy report on the electricity sector in Zambia, 2016

[43] Zambia Development Agency, Energy Sector Profile, 2014

[44] Freedom to Create, a policy report on the electricity sector in Zambia, 2016

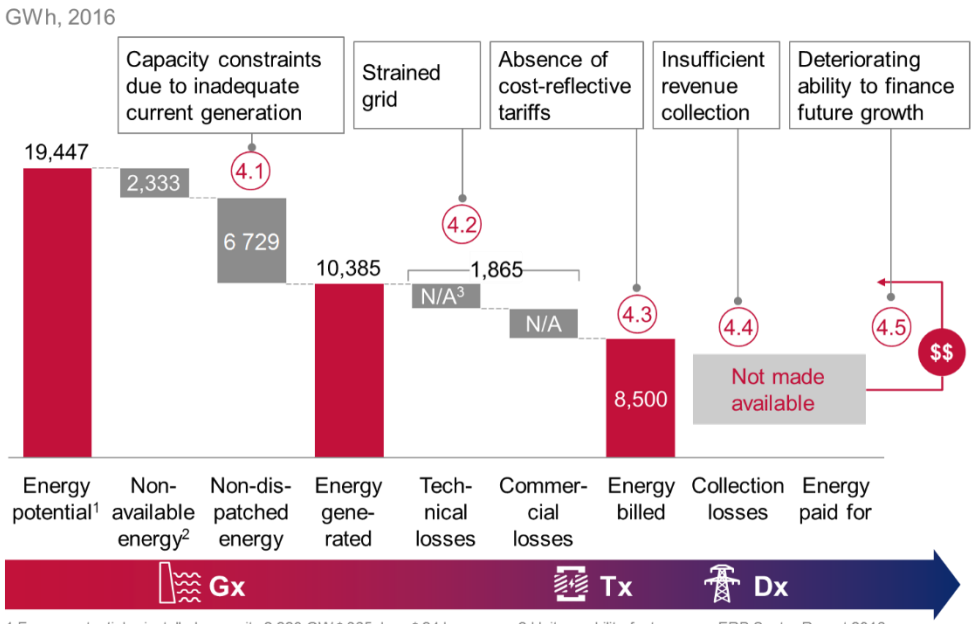
4 CHALLENGES TO ZESCO'S COMMERCIAL VIABILITY ALONG THE VALUE CHAIN

This chapter covers the critical challenges faced by Zambia's power sector along the value chain as it relates to ZESCO. A credit-worthy, commercially viable ZESCO could catalyze investment and growth in the overall sector. However, ZESCO's current performance constrains Zambia's ability to capture its full energy potential and support domestic growth and regional exports.

This chapter provides initial insights based on publicly available information at the time of writing, and draws largely on 2015 data from ZESCO's 2015 integrated report and 2016 statistical report. However, several elements could not be confirmed without access to ZESCO's management and ZESCO's managements' accounts, which were not available during the assessment period.

Exhibit 13 reflects ZESCO's performance along the value chain. The sections in this chapter (4.1 to 4.5) provide the major challenges: capacity constraints resulting from inadequate generation; a strained grid; absence of cost-reflective tariffs; insufficient revenue collection; and the deteriorating ability to finance ZESCO's future growth.

EXHIBIT 13: ZESCO'S PERFORMANCE ALONG THE VALUE CHAIN



4.1 CAPACITY CONSTRAINTS RESULTING FROM INADEQUATE GENERATION

As discussed in **Chapter 1 Overview of power in Zambia**, Zambia's total installed capacity in 2016 was 2,827 MW, which under normal circumstances is sufficient to address the peak load of 2,287 MW.[45] However, in drought situations part of the hydro fleet, which accounts for 99 percent of ZESCO's production cannot be used at full capacity. In 2015 this created a loss of 6,729 GWh of non-dispatched energy. In addition, ZESCO's planning and management of water resources during 2014 to 2015 exacerbated the impact of low rainfall, as 2016 had poor rainfall and the Kariba dam reservoir started on a low base that year. ZESCO added the Kariba North Extension in 2014 with a 360 MW installed capacity (two 180 MW turbines) and ran these turbines extensively, which depleted water reserves.[46] This created capacity constraints in 2015 and 2016. Although plant availability remained at 88 percent during the last drought (2015 to 2016), the capacity factors dropped to 53 percent.[47] ZESCO had to import expensive power from SAPP partners to fill the demand gap, which increased the cost of sales.

Power imports appear to be trending upwards. ZESCO imported 785 GWh in 2015 and 2,184 GWh in 2016.[48] Although no public data was available at the time of the assessment on the financial impact of the 2016 imports, ZESCO's 2015 integrated report showed an increase in import costs from USD four million in 2014 to USD 59 million in 2015. The volume increase from 2015 to 2016 implies that import costs were also larger in 2016 and had a greater financial impact on ZESCO.

The impact of ZESCO's emergency power imports contracts on its financial performance is an even greater concern. In 2015, ZESCO purchased 165 GWh of electricity at 18.35 USD cent/kWh – nearly three times Zambia's subsidized local tariff.[49] Substantial increases in load shedding during the drought also adversely impacted ZESCO's ability to meet the ERB's KPIs that related to tariff adjustments. This lowered future revenues because tariff adjustments were reduced based on the lower performance.

4.2 STRAINED GRID

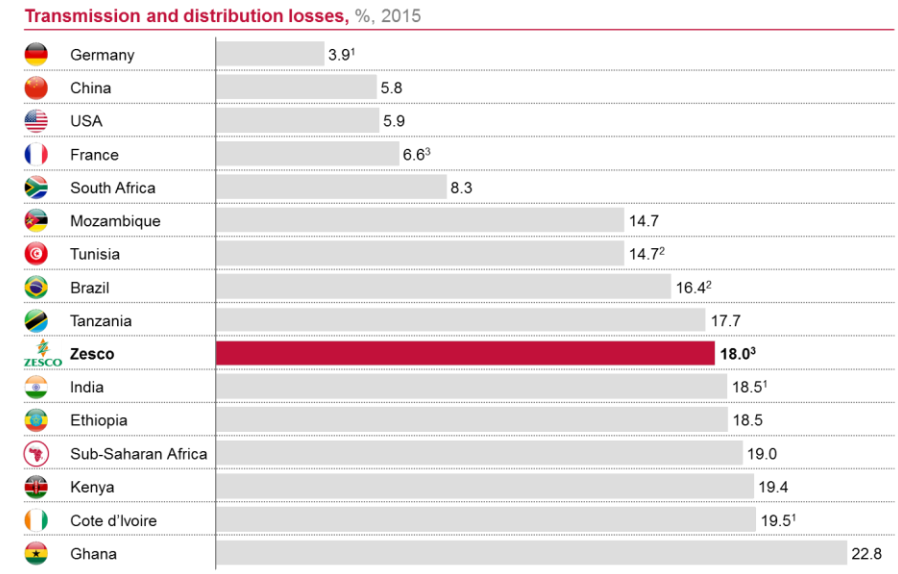
Recently, stakeholders have scrutinized the strength of ZESCO's transmission grid and raised concerns about how much intermittent renewable energy could be added without comprising grid integrity. ZESCO's total technical and commercial losses are eighteen percent.[50] Transmission losses rose from six percent in quarter one to seven percent in quarter four of 2015, which is higher than the target of five percent; data is not yet available for 2016. Distribution losses averaged eleven percent from 2015 to 2016, just under the target of twelve percent.[51]

While transmission and distribution values are comparable with those in other SSA countries (**Exhibit 14**) and are in line with ZESCO's KPI ceilings from the ERB, they exceed the desired loss levels of other emerging economies (e.g., China is at six percent and South Africa is at eight percent).

It is very difficult to identify the overall root causes for the transmission and distribution losses without input from ZESCO's management. However, reports and numerous discussions with stakeholders indicate that insufficient investment in the grid over the past decade is one of the main drivers of this increase.

[45] ERB Energy sector report, 2016, p. 57
[46] Interviews with local stakeholders and press searches
[47] ERB Energy sector report, 2016, p. 64
[48] ERB Statistics bulletin, 2016, p. 9
[49] Freedom to Create, a policy report on the electricity sector in Zambia, 2016, pp. 15 – 18
[50] ZESCO Technical Committee Terms of Reference, 2017, p. 6
[51] ZESCO 2015 KPI performance

EXHIBIT 14: COMPARISON OF ZESCO'S TRANSMISSION AND DISTRIBUTION LOSSES

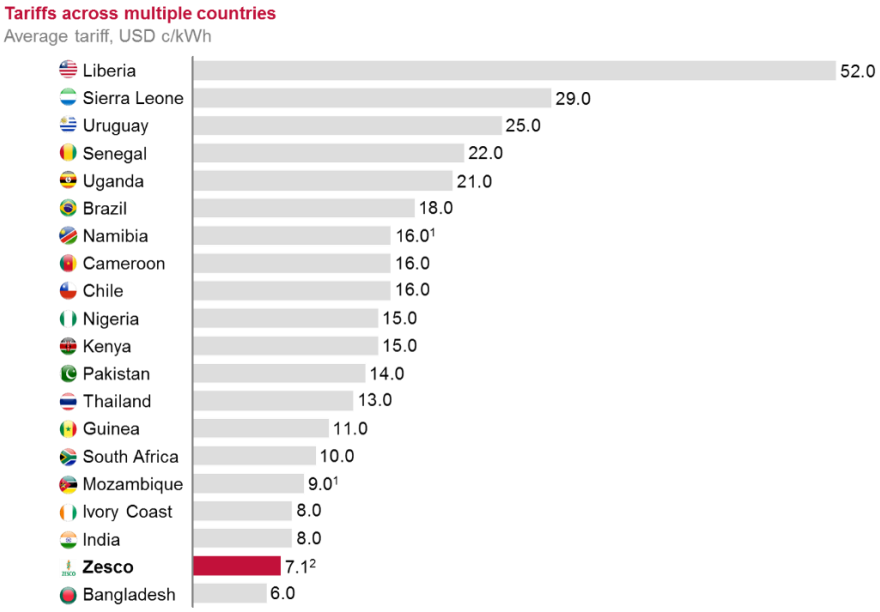


1 2014 figures
2 2013 figures
3 2016 figure
SOURCE: Enerdata, ECG, GridCo, TOR committee report 2016, World Bank

4.3 ABSENCE OF COST-REFLECTIVE TARIFFS

The common view in Zambia is that the power sector does not have cost-reflective tariffs. This is due to several factors, including a historically low tariff base (absolutely and relative to peers, as shown in **Exhibit 15**) and tariff increases that have trailed inflation (partially due to ZESCO not meeting the ERB's performance KPIs).

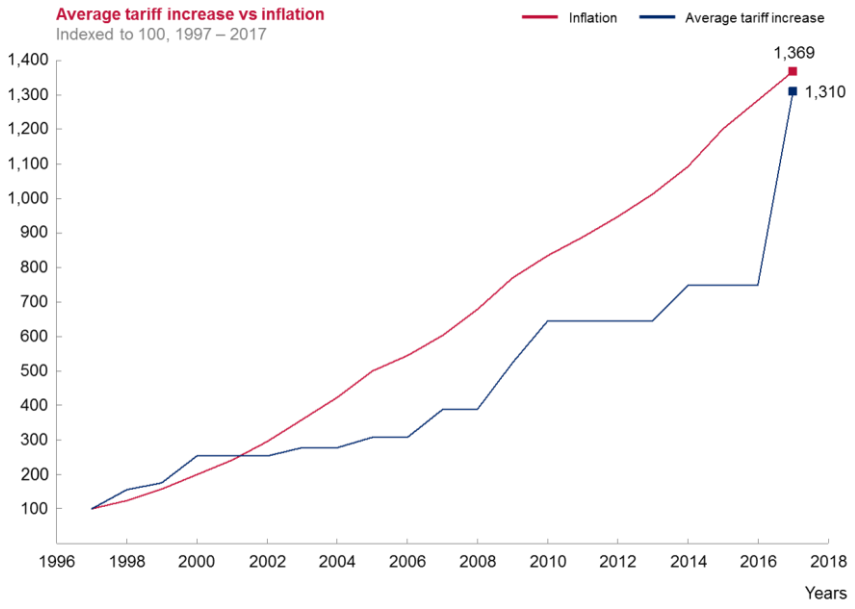
EXHIBIT 15: ZAMBIA'S AVERAGE TARIFF RELATIVE TO PEERS, 2015



1 As per 2016; 2 Average revenue per energy unit billed for 2015 (revenue / energy billed)
SOURCE: Country specific utility websites, Government of Liberia energy access plan 2012-20, ZESCO integrated report 2015 and press searches

Historical tariff increases have rarely tracked inflation closely – except in 2017 when the tariff was adjusted upwards by 75 percent, (**Exhibit 16**). The reasons provided by the ERB for this increase include the need to progress towards cost-reflective tariffs, and the fact that this was justified based on ZESCO's financial performance and anticipated electricity demand.[52]

EXHIBIT 16: INCREASES IN AVERAGE TARIFFS RELATIVE TO INFLATION, 1997 TO 2017



SOURCE: ERB sector report, World Bank development indicators

Defining a cost-reflective tariff depends on multiple factors and cannot be done without detailed analyses (e.g., it will vary depending on the condition of the utility's assets, the mix of technology used, the cost of capital, and future investment plans). However, a basic estimate that reflects the latest ERB report and the data from ZESCO's 2015 integrated report indicates that current tariff levels are still not cost-reflective.

At current levels of operational performance, the average revenue ZESCO earns per kWh is below the cost of production per kWh and leaves no margin for asset maintenance or expansion (**Exhibit 17**). In addition, the ERB has not granted ZESCO their requested tariff increases in full for at least four years because of performance against KPIs.

A comparison of the sum of ZESCO's costs per kWh (average 2015 operating costs plus costs to sustain operations) to its average revenues per kWh indicates that ZESCO's average revenues per kWh did not cover its operating costs, asset maintenance, future investments, and a return margin. Based on these reported numbers, ZESCO would have required an average tariff of at least 9.8 USD cents/kWh in 2015 instead of the 7.1 USD cents/kWh that it earned [53]/[54] (**Exhibit 17**). However, the Ministry of Energy's cost of service study in conjunction with the AfDB should provide guidance on adequate tariff levels, once it is completed.

Low electricity tariffs are an impediment to attracting IPPs to Zambia. A shift to cost-reflective tariffs would allow adequate returns to power producers, and could stimulate investment in the power sector.

[52] Lusaka Times, "ERB approves ZESCO's application to hike electricity tariffs by 75%, May 2017
[53] Depreciation and amortisation is included as an input into operating costs reflected in ZESCO's integrated report
[54] Average revenue per energy unit billed

EXHIBIT 17: COST RECOVERY OF ZESCO 2015 TARIFFS

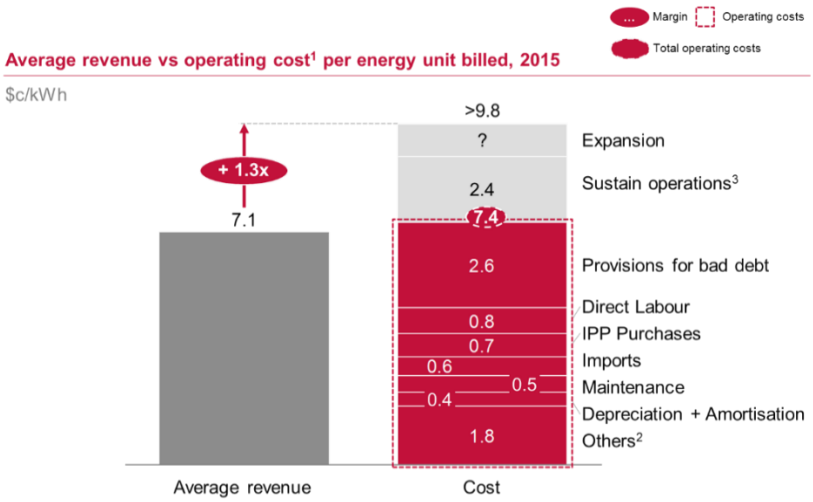
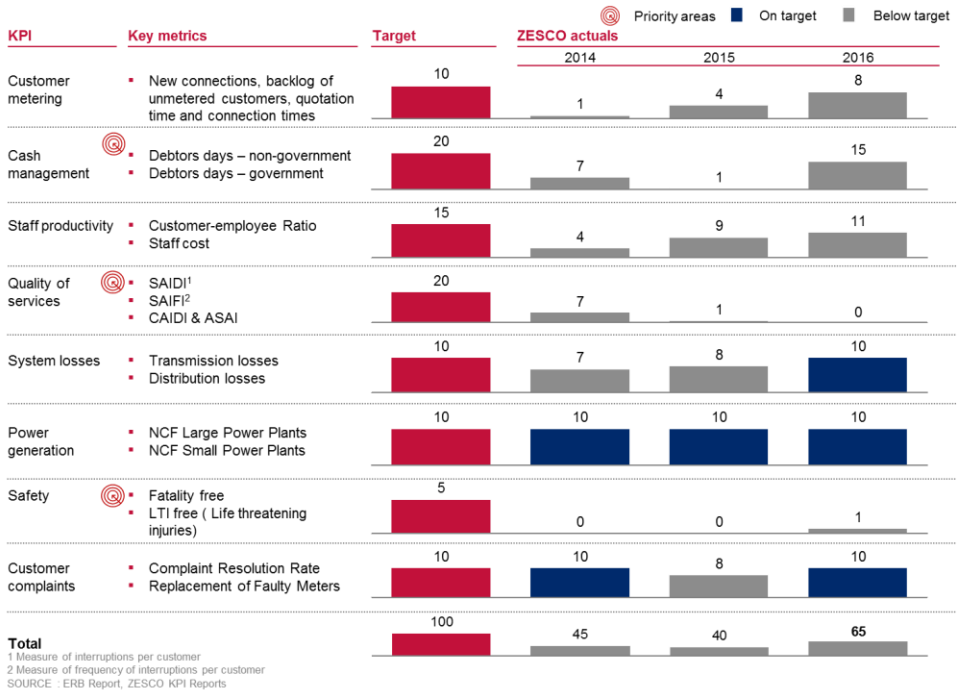


Exhibit 18 shows ZESCO's performance against the ERB's KPIs from 2014 to 2016, and its impact on tariff adjustment. Based on this performance, ZESCO has not been granted full tariff increases in recent years. The greatest gaps ZESCO needs to address are cash management, customer service, and the quality of its services. Customer metering and staff productivity were also below the target thresholds, and although ZESCO met its targets on system losses and power generation, these were not enough to support solid operational performance.[55]

EXHIBIT 18: ZESCO PERFORMANCE ON ERB KPIS



[55] ERB Energy sector report, 2016

4.4 INSUFFICIENT REVENUE COLLECTION

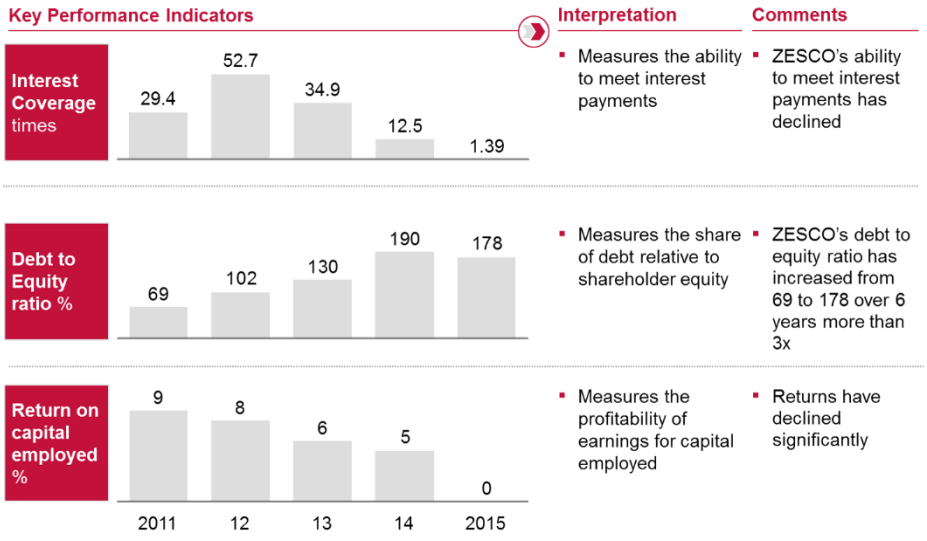
ZESCO also faces challenges in collecting bills from consumers, as reports and recent stakeholder interviews revealed. Although a shortage of data prevented calculating a precise collection losses percentage, significant provisions for bad debts in the profit and loss statement support this conclusion. These provisions increased by 3.5x from 2014 to 2015.[56] The mining sector and the central government have the highest debtors' days values, and collectively account for 90 percent of collections' losses in 2015. The government's debtors' days range from 728 to 842 days.[57] This analysis estimated these figures by comparing the 2015 billings with the receipts data provided in the 2015 financials. This issue is practically nonexistent with residential customers as most of them use prepaid meters.

Poor revenue collection affects ZESCO's cash flow in multiple ways. One of the most direct is when the failure to collect money from customers puts a potentially dangerous strain on ZESCO's liquidity (i.e., cash available to cover short-term debt). Revenue collection is also a core part of the ERB's cash management KPI. ZESCO is below target on this metric and is therefore unable to obtain a full tariff increase. It also has to set aside provisions for doubtful debts, which reduces the profits available to make operations economically viable.

4.5 DETERIORATING ABILITY TO FINANCE FUTURE GROWTH

ZESCO's debt levels appear to have grown rapidly, which is troubling when coupled with its declining returns. This combination undermines ZESCO's ability to service its short-term and long-term debts. As of 2015, ZESCO's operating profits had deteriorated to a point where there was concern about its ability to cover its interest payments. By that time, three of ZESCO's balance sheet KPIs, also important signals of investor perception, had rapidly deteriorated. They are interest coverage, debt-to-equity ratio, and return on capital employed (ROCE). **Exhibit 19** shows ZESCO's performance on each of these.

EXHIBIT 19: ZESCO'S DETERIORATING FINANCIAL PERFORMANCE, 2011 TO 2015



SOURCE : ZESCO integrated report, 2015

Each of these measures provides valuable information about ZESCO's performance and represents signals for investors' perceptions:

[56] ZESCO Integrated report, 2015, p. 56
[57] ZESCO Integrated report, 2015, pp. 29 - 30

- Interest coverage measures how many times operating profits can cover interest payments that are due. ZESCO's has significantly decreased, from nearly 53x in 2012 to only 1.39x in 2015, which means that its ability to meet interest obligations on debt has declined. Typical investment grade levels for interest coverage is 2.8x, or double ZESCO's level.

- The debt-to-equity ratio measures the relationship between an entity's debt and equity. This ratio has significantly increased from 69 percent in 2011 to 178 percent in 2015. From 2011 to 2012 the debt to equity ratio increased by 1.47x and from 2012 to 2015 the debt-to-equity increased by 1.74x. This indicates that ZESCO's debt burden has risen; however, this is only an issue if there are no corresponding profit increases to cover interest and debt principal payments. This situation appears to apply to ZESCO.

- The ROCE is calculated as the net profit after tax over the capital employed. ZESCO's declined from nine percent in 2011 to zero percent in 2015, which means that ZESCO does not make a profit from the capital it uses for its operations.

The combined expansion of the debt burden and the decline in capital profitability raises concerns about ZESCO's ability to meet additional debt payments going forward. This could negatively affect ZESCO's ability to raise funding independently for future growth, rather than relying more heavily on government funding or guarantees or on similar backstopping instruments – a challenge in a context where the Zambian national fiscal balance sheet is already stretched. The Treasury's recent budget statements announcing its decision to not increase government borrowing any more in the near future is just one example. ZESCO is also unable to become a credible offtaker for IPPs coming into the market and to provide a counter-party balance sheet that allows for private-sector investment.

4.6 IMPLICATIONS FOR THE COMMERCIAL VIABILITY OF ZESCO

The challenges described in this chapter make it clear that ZESCO does not currently meet the criteria for a commercially viable entity, and is unlikely to achieve them in the future unless it puts forward a long-term transformation plan. To be effective, such a plan should be tied to financial metrics that rating agencies and investors typically associate with commercial viability (**Exhibit 20**).

The market's view of ZESCO's current performance in terms of the requirements for commercial viability can be summarized by contrasting ZESCO's current performance to a rating agency's expectations for an investment-grade equivalent rating. Rating agencies such as Moody's have criteria, in the form of a credit rating, for regulated utilities to determine whether these utilities are deemed to be of "investment grade" quality. This rating changes over time as the entity's strength and debt load changes. If an entity takes on more debt than it can handle or if its earnings outlook weakens, the company's rating will be lowered.[58]

Zambia and its public utilities are rated B3 (equivalent to "speculative and high credit risk," two notches below investment grade) (**Exhibit 20**). ZESCO does not meet any of the relevant metrics, e.g., its CAPEX / fixed assets ratio is 30 percent vs. a target of eight percent or less, and its EBIT / net debt is below one percent versus a target of more than eleven percent.

These metrics assess whether the company can meet its debt obligations, continuing to operate, and invest in new assets. They include:

- CAPEX to fixed assets indicates whether investments into new assets are sustainable given the current asset base. A high CAPEX to fixed assets ratio suggests that expansion projects are not sustainable for the balance sheet and will put the business under strain.

- Net debt to fixed assets indicates the share of assets that are financed through debt. Rapid expansion of assets combined with large debt financing is typically a concern, as interest payments and principal payments become due regardless of operational performance.

[58] Following Investopedia and Moody's definitions

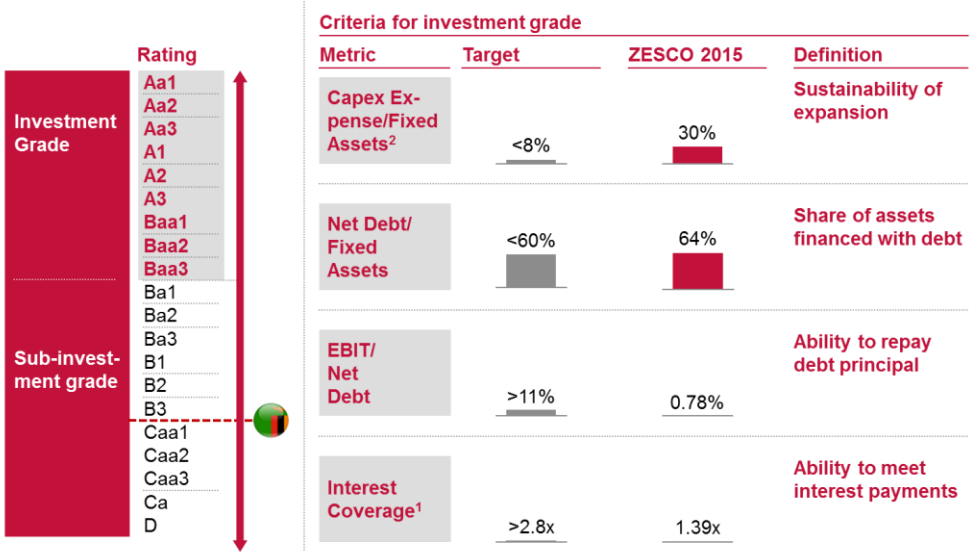
- EBIT to new debt indicates the level of operating profits available to cover the debt book and an organization's ability to pay off the principal on debt. Rapid expansion with debt and poor operating profits are a concern as these suggest an increased likelihood of default on debt payments (a negative sign for investors).

- EBIT to interest expense indicates the ability of a company to pay its current interest payment with operating profits. Interest coverage is an indication of the margin of safety an organization has to meet its financing costs.

EXHIBIT 20: ZESCO'S ESTIMATED PERFORMANCE ON RATING CRITERIA FOR REGULATED UTILITIES AS OF 2015

ESTIMATES

Proxy estimates, based on Moody's criteria for regulated utilities (using EBIT as a proxy for FFO)



1 EBIT used as a proxy for Funds from Operations (FFO)
2 Scale and complexity of capital program metric
SOURCE: Moody's methodology paper & Moody's website

The performance trajectory described above has worsened over the past five years. Given the current performance level and the potential effects if the trend continues, four major implications emerge for ZESCO and the Zambian power sector:

1. It is unlikely that ZESCO can sustain the investments needed to meet Zambia's demand for electricity in the near-term.

2. It is unlikely that ZESCO can be considered a creditworthy off-taker for potential private-sector power producers.

3. The proposed creation of an ISMO may not have the desired effect of levelling the playing field for private sector entrants if ZESCO is not commercially viable, as the ISMO will require government support and guarantees to sign purchase agreements. When countries carve out an ISMO from their national utility, the first step is typically to ring-fence generation, transmission and distribution activities operationally and financially (i.e. run these internally as separate business units). Then, transmission is typically pulled out as a separate entity to operate as a single market operator and single buyer (purchasing power from the utility, and from IPPs). While this is a step forward towards facilitating private sector participation, it will only yield the desired increase in private sector participation if ZESCO transforms its intrinsic performance. The creation of an ISMO is not a means to attain this transformation. Even in this new structure, ZESCO will require the same level of government support that ZESCO currently requires, unless it puts forward a transformation plan. An ISMO will create more transparency and independence in the selection process for IPPs but will require a commercially viable ZESCO to pay its bills (as the main distributor). In the absence of a commercially viable ZESCO, the Government will have to provide the financial support needed to ensure the ISMO is a creditworthy off-taker.

4. ZESCO's ability to put forward a credible plan to achieve commercial viability in the next few years, together with an effective delivery mechanism, is critical for the sector's future growth and aspirations.

5 CHALLENGES IN DELIVERING ELECTRIFICATION

This chapter explains the status of electrification in Zambia and the country's targets in terms of electrification. It also examines the roles of key stakeholders, and explores the challenges and issues that need to be resolved to deliver additional grid and non-grid connections. It concludes with the primary implications for the stakeholders in the sector.

This chapter refers to three types of electrification technology that can provide power to non-electrified communities:

1. Grid electrification, whereby households are connected to existing distribution lines or new lines. Typically, this is the most economical option for households in large, dense settlements that are close to the existing grid.

2. Mini-grids, a small-scale source of electricity generation (ten kW to ten MW) that serve a localized group of customers (e.g., 100 households) via a distribution grid that can operate in isolation from a national electricity transmission network. Mini-grids are typically the most economical option for households in dense settlements far from the current grid. Mini-grids support anchor loads better than off-grid options, and their infrastructure can be used if or when the settlement is connected to the main grid.

3. Solar home systems, stand-alone photovoltaic systems that supply amenity power for lighting and appliances to remote, sparsely concentrated populations. They usually operate at a rated voltage of 12 V direct current (DC) and provide power for low-power direct-current appliances such as lights, radios, and small TVs for about three to five hours a day. Typically, they are the most economical options for households in small settlements far from the current grid. They are also potentially the fastest option to roll out at scale.

Discussions with REA, publicly available information, and meetings with development partners in Zambia helped shape this chapter. In several instances, inconsistencies surfaced in informal discussions, e.g., relating to REA's and ZESCO's mandates for last-mile electrification. When this has occurred, the report relies on the official positions communicated by REA.

5.1 ELECTRIFICATION STATUS AND TARGETS

Zambia is facing significant challenges due to its shortage of national grid coverage, particularly in rural areas. With a population of 15.5 million in 2015, it has an estimated number of 3.1 million households (assuming an average of five persons per household).[59] Its population density is low, with an average of twenty people per square kilometer, which is even lower in rural areas. This poses a challenge to electrification because of the increased CAPEX needed to reach disperse consumers.

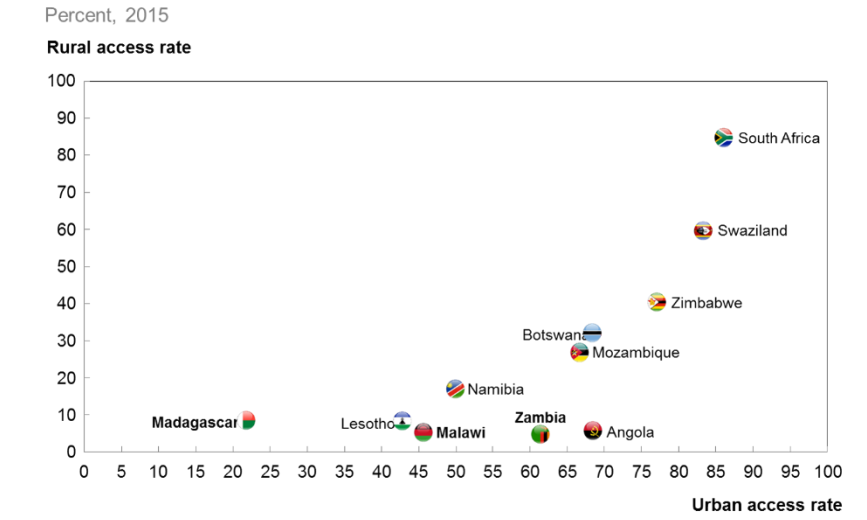
As of 2015, the Power Africa Roadmap estimated that nearly 2.3 million households did not have access to the grid in Zambia, which equaled an overall electrification rate of 27 percent. Zambia's urbanization rate is nearly 41 percent, meaning there are about 1.4 million urban and 1.8 million rural households, with an urban access rate of 62 percent and rural access rate of 4.5 percent. [60/61] As referenced in Exhibit 21 below, these values are low even relative to other Southern African countries, particularly in terms of rural electrification.

Zambia has set a target of an urban electrification rate of 90 percent and a rural electrification rate of 51 percent by 2030 (for a total electrification rate of 66 percent). Urban access has been growing at nearly five percent per annum from a base of 50 percent in 2010 to the current 62 percent.[62] Rural access has been growing faster, at nearly eight percent per annum, although it started from a much lower base of 3.2 percent in 2010. At the current rate of population growth, that translates to nearly 1.1 million new urban connections and nearly 1.3 million new rural connections by 2030.[63] To achieve this, Zambia would have to connect nearly 74,000 urban (growing at nearly four percent per annum), and nearly 93,000 rural (growing at nearly eighteen percent per annum) households per annum. This is an ambitious goal, particularly for rural connections which would drive access from 4.5 percent to 51 percent over the next 13 years. In 2014, based on International Energy Agency (IEA) rural access

[59] Republic of Zambia Central Statistical Office, Living Conditions Monitoring Survey Report, 2015
[60] Republic of Zambia Central Statistical Office, Living Conditions Monitoring Survey Report, 2015
[61] World Energy Outlook 2015
[62] World Energy Outlook 2015
[63] Three percent per annum, reaching a total population of 25.3 million by 2030

growth rate figures, Zambia connected ~12,000 rural households. Further, the REMP estimates that it would cost USD 50 billion per annum to meet rural connection targets alone.

EXHIBIT 21: URBAN AND RURAL ELECTRIFICATION RATES, 2015



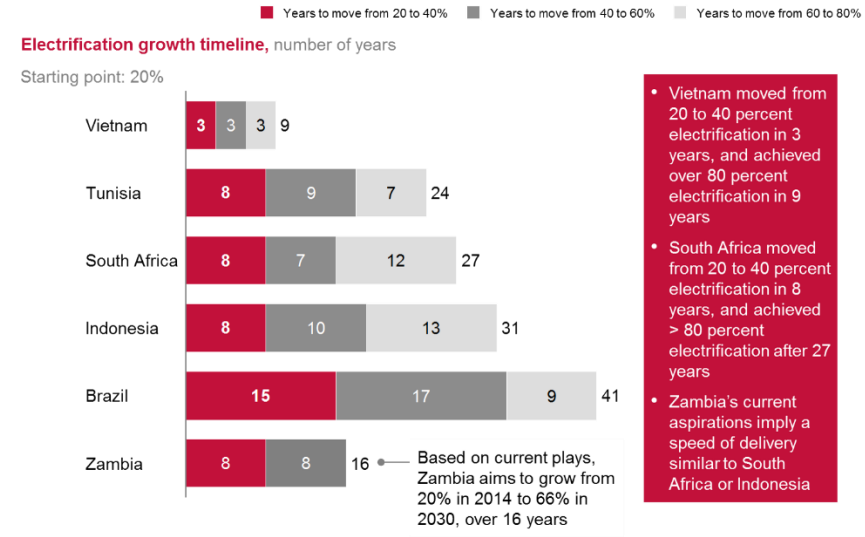
1 Rural is split based on distance to transmission grid; if household is <10 km to the grid, it is categorized as "Rural near grid"; if it is >10 km, then it is categorized as "Beyond the Grid"

SOURCE: World Bank, IEA, World Energy Outlook 2015

Based on other countries' experience (see **Exhibit 21**), such a step-change in electrification is achievable but requires significant program management capabilities and innovative contractor management. For example (see **Exhibit 22**):

- **South Africa increased electrification from 35 percent to 84 percent of total households between 1990 and 2011** (from 12 percent to 57 percent of rural households). It exceeded the government's target of 1.75 million connections from 1994 to 2000 through a self-funded and managed program. The effort delivered, on average, a new connection every three seconds, a pole every ten seconds, and 200 meters of cable every minute. It also created an environment where the most successful contractors competed and earned the right to additional connections, and were strongly incentivized to deliver connections
- **Kenya increased electrification from 25 percent to above 60 percent from 2011 to 2016** (five years), connecting on average more than 500,000 customers per year. In 2016 alone, it made more than one million new connections. Transmission lines and transformers were built with extra capacity to enable future rapid deployment of further drop-down lines. It also focused on informal settlements near existing transformers, and subsidized connection fees with support from the Global Partnership on Output-Based Aid and Last-Mile Connectivity programs. In addition, it used public education activities to attract customers that could afford connection fees and future consumption. Around 400 active contractors supported the electrification efforts.
- **Vietnam increased electrification access from twenty percent in 1996 to 80 percent in 2004, achieving 100 percent rural electrification in 2011.** The Government established and equipped a holding company, Electro Vietnam (EVN), to handle generation, transmission, and distribution expansion. EVN also coordinated with communities by building medium voltage (MV) systems with up to 22/35 kV substation outlets and by involving the local authorities through local distribution utilities (LDUs) to manage low voltage (LV) systems. The flexibility to manage, construct, and operate local electricity was a critical component of the rapid expansion of access to electricity.

EXHIBIT 22: EXAMPLES OF ELECTRIFICATION TIMELINES



Source: KPLC – Electricity Connection Data July 2015; team analysis; Brighter Africa

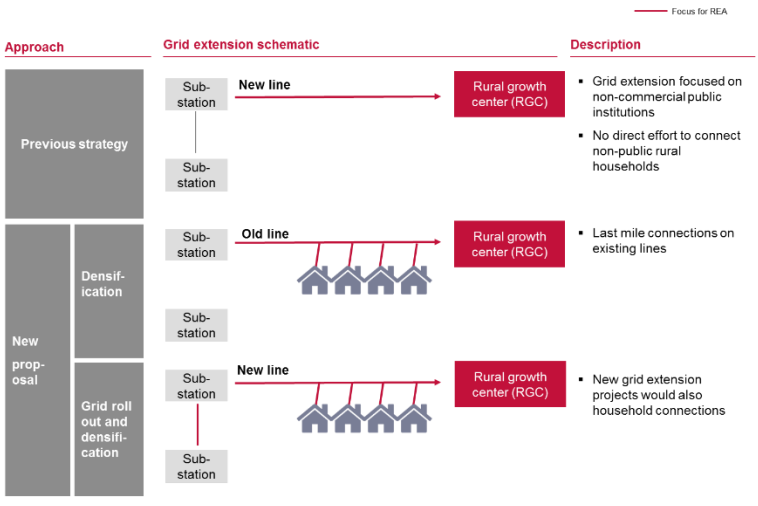
5.2 KEY STAKEHOLDERS IN ELECTRIFICATION DELIVERY

The main stakeholders that deliver connections in Zambia include grid (REA and ZESCO) and off-grid, government agencies (across both), and the private sector (off-grid only).

Grid rollout is driven by the public sector through REA and ZESCO. ZESCO has a commercially-driven mandate and concentrates on the delivery of connections to economically-viable areas. ZESCO is responsible for both urban and rural areas, but tends to focus on urban connections**. REA** is tasked with developing and implementing a plan to electrify rural areas**.**

REA's original strategy, according to the REMP (2008), was to focus on grid extension to rural growth centers (RGCs) (see **Exhibit 23**). It connected public institutions (e.g., schools, health centers, and government buildings) and then handed the lines to ZESCO to complete the last-mile connections. REA's strategy is currently under review and may expand to target more last-mile connections on the lines it has already built. Interviews with REA have revealed two proposed changes to the revised strategy: firstly, to increase the connections on already-existing lines (densification) to RGCs by extending lines to private properties en-route and at the RGCs; and secondly, to ensure that new lines in rural areas connect to both RGCs and individual households.

EXHIBIT 23: REA'S STRATEGY, 2017



SOURCE: REA interviews; REMP (2008)

In the off-grid sector, a mix of public and private sector actors deliver mini-grids, commercial standalone solutions, and solar home systems. The main players include, but are not limited to:

5.2.1 PRIVATE SECTOR

Private sector players deliver primarily mini-grid and solar home system electrification solutions. These players include:

- **FENIX,** a US-headquartered company with offices in Uganda and Zambia, provides solar home systems with a PAYG model. FENIX collaborates with MTN to leverage its mobile money services for payments, and offers a range of product packages. The company was recently acquired by ENGIE.
- **VITALITE** is headquartered in Zambia and has three main offerings: a solar home system offering (no wide range of products but a single package), a range of energy-efficient cooking solutions, and an offering to smallholder farmers through a "suite of productive use farming products" and trainings. VITALITE partners with mobile providers to deliver PAYG payment solutions.
- **d.light Energy** is present across four hubs in Africa, China, South Asia, and the United States. d.light provides three types of solar home systems: the D20, with two plugs and a portable lamp; the D30, which includes a solar panel, a mobile-charging battery pack, three solar lights, three light switches, a torch, a FM radio, and is offered on a PAYG model; and the X850, which also includes a super-bright tube light, fully-customizable lamp brightness, linkable bulbs, ultra-efficient accessories, and an appliance. d.light is in the process of completing its contracting with the Beyond the Grid fund to start distribution in Zambia as of October 2017.
- **Standard Microgrid** is headquartered in the US and provides communities with a ten kW micro-grid that can be deployed in three days. Containers have the capacity to deliver power to upward of 150 homes.
- **Emerging Cooking solutions (ECS), now SupaMoto Energy**, is headquartered in Sweden and provides stoves that use pellets made from forestry waste to reduce charcoal-based cooking. SupaMoto also provides customers with solar home systems with a 24 W panel.
- **Hydro mini-grid:** Zengamine Power Limited (ZPL) owns and operates the 750 kW Zengamena mini-grid hydro plant in the Northwestern province. The plant was commissioned in 2007 and sourcing water for its turbines from run of the river rather than a water reservoir dam

5.2.2 PUBLIC SECTOR AND PUBLIC-PRIVATE PARTNERSHIPS

Looking at public institutions, REA and ZESCO also have activities in the mini-grid sector. REA and the IPP Zengamina Power Ltd (ZPL) own and operate mini-grids in Zambia. ZESCO currently owns and operates four mini-hydro plants that supply power to the grid, namely: Lusiwasi twelve MW, Musonda Falls five MW, Chishimba Falls six MW, and Lunzua 0.7 MW. REA has been testing the application of mini-grid technology in remote areas since 2008 with the construction of a mini-solar plant at Mpanta village in Samfya district, Luapula province in 2014. The solar mini-grid with 60 kW generation capacity is targeting approximately 500 households, public facilities and businesses.

REA is currently planning to build two mini-solar plants: one in Lunga district with 300 kW generation capacity targeting 1,000 households, and another in Chunga camp with 200 kW generation capacity targeting 500 households. REA is also planning to build a hydro mini-grid in Kasanjiku with 620 kW generation capacity targeting 2,000 households in the near future.

5.3 CHALLENGES IN DELIVERING GRID CONNECTIONS

Grid-based electrification is typically the most economical solution to provide power for households in large, dense settlements that are close to the existing grid. Under the most recent REMP (2008) 90 percent of new connections would be delivered via grid electrification. However, the main agents that implement grid connections (ZESCO and REA) face several challenges.

5.3.1 ZESCO CONNECTIONS

ZESCO has a long backlog of connections in urban and peri-urban areas (estimates ranged between 10,000 and 35,000 over the past three years), **and long average connection times of >150 days**.[64/65] The root causes of these delays cannot be determined without direct discussions with ZESCO, but stakeholder discussions and reports provided multiple insights into possible drivers. These include: infrastructure constraints in various parts of the country (e.g., obsolete or aging transformers and MV feeder lines); and infrastructure theft and vandalism, which cause delays (e.g., in the Lusaka and Copperbelt region). It would also be helpful to know what ZESCO's internal operating model is for making these connections, and how effective the model is.

Another issue is the lack of a financial incentive for ZESCO to deliver last-mile connections in rural areas, where many homes receive free basic electricity levels of 200 kWh per connection. Governments typically support low-income households to meet basic electricity needs up to a certain threshold. In Zambia, the threshold is high relative to its peers. In Zambia, residents receive free electricity below 200kWh per connection, compared to a threshold of 50kWh in South Africa. In Kenya, electricity is highly subsidized below consumption of 50kWh per connection, and increases in cost thereafter. This level of consumption supports lighting, communication, basic refrigeration devices, and entertainment such as radio and TV. It is likely to exceed what the majority of rural households can probably afford in the near future. Unsurprisingly, grid-based rural electrification has stagnated. Incentivizing ZESCO to drive connections in rural areas and incur the associated costs will require cost-reflective tariff allocations from the ERB. The increasing cost of connections in rural / low population density areas, and their higher operations and maintenance costs would further deter ZESCO's activities in this area.

5.3.2 REA CONNECTIONS

REA has limited capacity and funding to deliver last-mile connections in rural areas. The proposed changes in REA's strategy that could help alleviate some of these issues have not yet been approved. REA is currently contemplating shifting from delivering connections to public institutions in RGCs to delivering last-mile connections to the households surrounding these institutions. Its earlier strategy was to hand these lines over to ZESCO. REA has only obtained funding for 22,000 last-mile connections so far, and will need to demonstrate its ability to scale-up these efforts to receive further support from development partners.

The European Union is currently leading an effort that is reviewing the interface between REA and ZESCO on last-mile connections. Different views exist on the respective roles that ZESCO and REA should take (e.g., whether ZESCO would

[64] Based on press searches and in-country interviews, though not with official ZESCO figures
[65] World Bank Ease of Doing Business indicator, 2016

remain the implementing agent but be financially incentivized by REA to complete rural last-mile connections, or whether REA would remain the implementing agent); no conclusion has been reached.

REA's shift from turnkey contracting to labor-based contracts is contributing to delays in its delivery of new line-extension projects. While a turnkey contract is a tender that requires the contractor to be responsible for the project end-to-end, labor-based contracts require REA to be more involved in the delivery of new line-extension projects by managing the procurement of and supply chain for all project materials. This is a delicate transition and could create a risk to the quality and timeliness of REA's delivery of new projects; REA will need to demonstrate its ability to implement labor-based contracts (which is significantly more complex than turn-key contracts) to maintain its role in grid-based electrification and expand its mandate to last-mile connections.

5.4 CHALLENGES DELIVERING OFF-GRID CONNECTIONS

The persistent low levels of rural electrification in Zambia have increased development partners', public institutions', and private actors' interest in providing off-grid solar and hydro solutions. The greatest share of interest has been in off-grid solar solutions given Zambia's high irradiation levels. Two main technology options – mini-grids and solar home systems – can help provide power to non-electrified areas that possess fundamentally different characteristics, but players face challenges in scaling up their products in the Zambian off-grid market.

5.4.1 MINI-GRIDS

Private mini-grid actors have limited activity in Zambia because the country does not have a structured program to encourage mini-grid development, has trouble finding sustainable financing schemes for them, and does not yet have a complete regulatory framework.

Zambia still lacks a structured mini-grid scale-up program. No comprehensive assessment exists that would identify potential sites and potential concessions across the country, something that is typically conducted through a geospatial exercise. The REMP (2008) and the JICA Power System Development Masterplan (2010) provide an initial overview of the off-grid opportunity, but assessments need to be updated given the evolution of off-grid technology (e.g., these plans do not consider mini-grid solar as a potential technology). Neither masterplan includes mini-grid solar as an option for rural electrification (i.e. the REMP cites the limited availability of local suppliers of any solar related products in 2008 making solar options prohibitively costly). New entrants find that they need to interact with REA, ZESCO, and OPPPI. While the OPPPI would typically act as a one-stop shop for new IPP entrants (e.g., provide support in obtaining licenses and permits, facilitation, and technical support in environmental impact assessments), it only covers projects greater than ten MW, which provides very limited support for mini-grids.

The difficulty of finding a sustainable financing scheme is frequently combined with a burdensome tariff process. Based on the 2016 Overseas Development Institute/Principal Action Report, the current tariff approval process is a relatively complex procedure at the ERB and prevents private actors from freely setting cost-reflective tariffs.[66] In most countries, mini-grid tariffs are not set to main grid tariffs. The REFiT policy that the Department of Energy is developing should create an incentive framework for renewable generation assets that are connected to the grid. However, this policy does not cover off-grid assets (according to the latest reports in 2016). Further discussions with the ERB would be required to understand the tariff process for mini-grids and potential changes to it going forward.

An incomplete regulatory framework deters mini-grid players from entering the market. Some of the regulatory areas that still need to be addressed include differentiation between the licenses and permits for mini-grids versus power plants, guidance on how mini-grids will interact with the grid, and authorizations on land use. For example, Zengamina mini-hydro obtained a lease for the plant without the right of way for the distribution network, which increased the challenge of rolling out end-user connections.[67] These types of clarifications are necessary parts of an enabling environment.

[66] Report prepared jointly by Oversees Development Institute, Global Off-Grid Lighting Association (GOGLA), Practical Action and SolarAid in 2016 that outlines challenges in accelerating access through off-grid solar

[67] ENEA, 2015

5.4.2 SOLAR HOME SYSTEMS

Solar home systems players also face major issues in Zambia that ultimately impact the price charged to end-users, and the players' ability to scale-up. Donors' (e.g., the EU and UK) efforts are addressing these issues, but have not yet resolved them. Based on experience from other emerging markets, examination of previous reports on challenges in Zambia and initial discussions with the solar home systems players about their barriers to scale-up, a list of 21 barriers, shown in **Exhibit 24**, was identified. While further engagement with these players is still needed, initial discussions identified two thematic areas: firstly, sector-wide issues driven by the regulatory framework and policy environment; secondly, company-specific issues affecting their ability to scale up, such as customer ability to pay and awareness, supply chain and route to market and access to finance. These themes can be organized under four main challenges, detailed further below:

1. **Regulatory framework and policy environment relating to Solar Home Systems.** In terms of the regulatory and policy environment players highlighted two key issues. Firstly, the absence of clear commitment on the role of off-grid in national electrification plans and the willingness to create a level playing field. Secondly, import duty related issues, such as inconsistent application of import duty exemptions and incomplete exemption coverage (e.g., only applied to batteries and panels) that drives up costs.

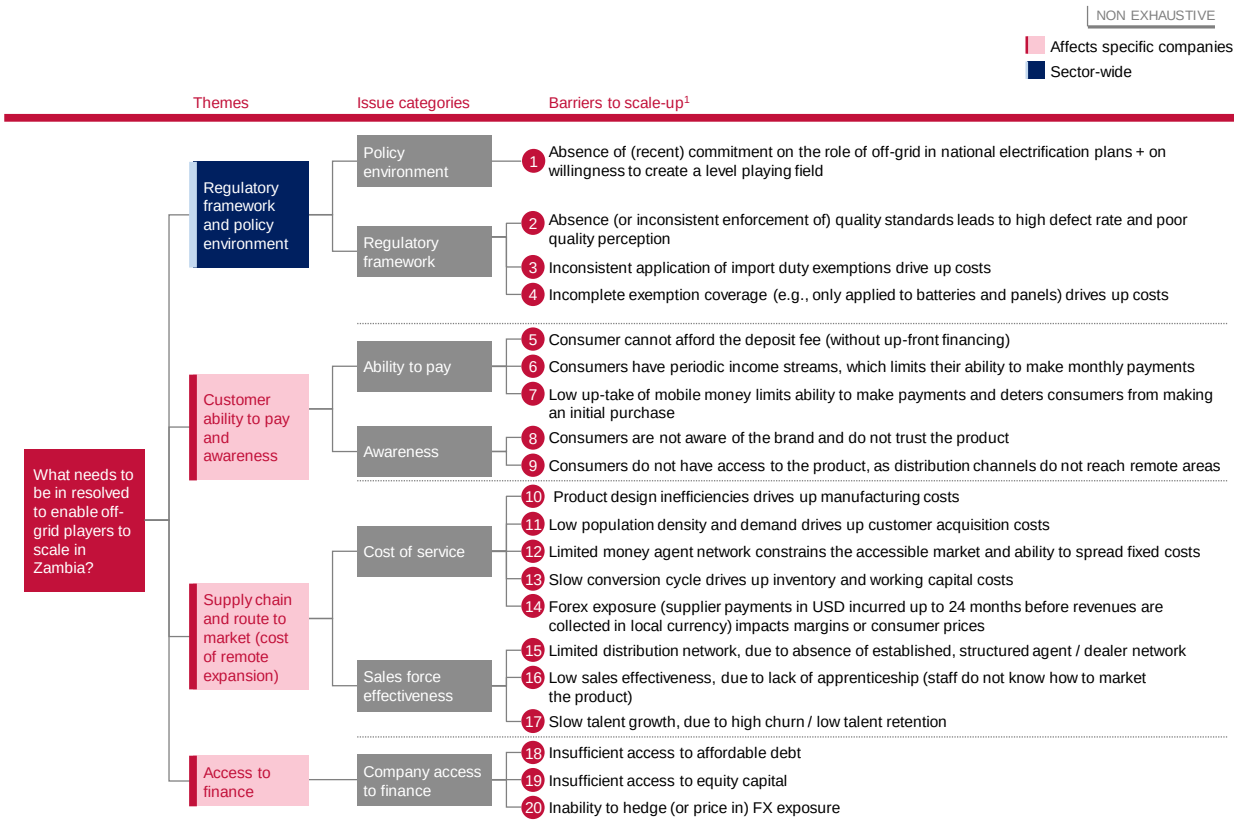
2. **Customer ability to pay and awareness.** The low level of mobile penetration in Zambia (fourteen percent of adults currently use mobile money services)[68] poses a challenge for companies looking to overcome low incomes of rural households by providing Pay-As-You-Go (PAYG) options. However, given the low level of mobile money penetration customers must make a two-fold decision when using mobile money solutions to purchase a solar home system; first deciding to purchase a solar home system and secondly to fund the purchase using mobile money.

3. **Supply chain and route to market (cost of remote expansion).** Three major issues were raised by players. Firstly, low population density and demand drives up customer acquisition costs high transport costs. Secondly, slow conversion cycle drives up inventory and working capital costs. The conversion cycle is approximately 2.5 years: products take 6 months between first order and arrival in Lusaka, and then 2 years to be fully repaid. [69] Thirdly, low sales effectiveness, due to lack of apprenticeship and high staff turn-over.

4. **Access to finance.** Players acknowledged that the support from the Beyond the Grid Fund has helped to alleviate immediate working capital constraints, but that to support their scale-up costs it would help to gain access to affordable local currency debt. The interest rates offered by local banks are still unaffordable for most players, and this could become a constraint in the medium term.

[68] Finscope, 2015
[69] Solar Home System company interviews

EXHIBIT 24: BARRIERS TO SCALING AND UPTAKE OF SHS IN ZAMBIA



1 Comprehensive list that needs to be assessed for the Zambia context

SOURCE: Interviews with SHS providers

5.5 IMPLICATIONS

The challenges described above have two important implications that the Government of Zambia should address:

1. If Zambia aims to attain 90 percent electrification in the next thirteen years. It should look at the experiences of other countries such as South Africa and Vietnam. These countries had structured programs with clear milestones and plans, and some innovative contractor management models. In addition, it will be critical to specify the mandates and incentives for REA and ZESCO to execute these connections.

2. Off-grid technologies present an exciting opportunity to accelerate the delivery of connections in Zambia, but will only take off if the Zambian authorities resolve a number of targeted challenges. For mini-grids, the onus is more on promoting the private sector's involvement (e.g., develop a structured program to encourage mini-grid development, find sustainable financing schemes, and address regulatory gaps). For solar home systems, the challenge is to find ways to maintain low end-user prices and resolve staffing issues in remote areas.

APPENDIX

DISCUSSIONS WITH STAKEHOLDERS

	Stakeholder name	Role	Organization
Development partners	Adam Grodzicki	Head of Infrastructure Section	European Union
	Alfredo Baldini	Resident Representative	IMF
	David Sula Mpundu	Energy advisor	USAID mission
	Geoffrey Smith	Senior economist	World Bank
	Jenny Hasselsten	Energy specialist	World Bank
	Joseph Kapika	Senior energy specialist	World Bank
	Magdalena Svensson	First secretary – Programme Officer Energy	SIDA
	Mike Banda	Programme Officer Finance and Admin	SIDA
	Mwepe Kapumpa	Program Officer – Infrastructure and Training	JICA
	Pepakaye Bardouille	Senior Operations Officer	IFC
	Peter Rasmussen	Principal country economist	AfDB
	Stephen Neu	Director	KfW
	Steve Beel	Cities, Energy and Infrastructure Advisor	DFID
	Takashi Hansaki	Assistant Resident Representative	JICA
	Will Pearson	GET FiT Zambia – Program Coordinator	KfW
Public sector	Agnelli Kafuwe	Energy Officer	Ministry of Energy
	Alfred Mwila	Permanent Secretary of Energy	Ministry of Energy
	Arnold Simwaba	Director of Energy	Ministry of Energy
	Clement Sasa	Manager	Office for Promoting Private Power Investment
	Florence Sikute	Acting Senior Energy Officer	Ministry of Energy
	Michael Mulasikwanda	Principal Power Development Officer	Ministry of Energy
	Misheck Mubuyaeta	Electrification Officer	Ministry of Energy
	Patrick Mubanga	Director of Technical Services	Rural Electrification Authority
Utilities, IPPs & SHS providers	John Fay	Director	VITALITE
	John Foye	Country Lead	FENIX
	Silvester Hibajene	Head of International and Government Relations	Copperbelt Energy Corporation
Power Africa and USAID SAEP	Chris Mubemba	Country Manager	USAID SAEP
	Garth Broome	Advisor to ZESCO	Power Africa
	Jorry Mwenechanya	Team Lead for Outcome 4	USAID SAEP
	Liz Pfeiffer	Program Manager	USAID SAEP
	Tony Iskarpatyoti	Advisor to Ministry of Finance	Power Africa
	Vibhuti Jain	Financial Solutions Lead	Power Africa
	Wayne Mikutowicz	Team Lead for Outcome 2	USAID SAEP

PUBLICATIONS USED IN THIS REPORT

	Report title	Publisher	Year of publication
Zambia reports & policy documents	Load shedding impact study	Energy Regulatory Board	2017
	Zambia's electricity sector reforms	Ministry of Energy	2017
	ZESCO tariff application	Energy Regulatory Board	2017
	Energy Sector Report	Energy Regulatory Board	2014 - 2017
	Statistical bulletin	Energy Regulatory Board	2016
	2015 Living Conditions Monitoring Survey	Central Statistics Office	2016
	Selected socio-economic indicators report 2015	Central Statistics Office	2016
	Solar regime licensing revised	Energy Regulatory Board	2016
	Electricity tariff determination guidelines	Energy Regulatory Board	2016
	Opportunities in the energy sector in Zambia	Ministry of Energy	2015
	Micro-grids for rural electrification	Energy Regulatory Board	2015
	Electricity infrastructure development for economic growth	Zambia Electricity Supply Corporation Limited	2015
	Energy sector profile	Zambia development agency	2014
	Population and Demographic Projections 2011-2035	Central Statistics Office	2013
	ZESCO Integrated Annual report	Zambia Electricity Supply Corporation Limited	2012 - 2015
	REA strategic plan	Rural Electrification Authority	2014 - 2018
	REA annual report	Rural Electrification Authority	2015
	Status of rural electrification in Zambia	Rural Electrification Authority	2017
	Private sector participation in power in Zambia	Office for Promoting Private Power Investment	2017
External reports	Pilot Zambia initiative program framework	Africa Development Bank	2017
	Power Africa annual report	Power Africa	2015 - 2017
	Developing Mini-grids in Zambia	ENEA, Practical action	2016
	Increased Access to Electricity Services Project	World Bank	2016
	Freedom to create	ESI of the National University of Singapore	2016
	Off-grid solar country briefing	Global off-grid lighting association, solar aid	2016
	Country fiche annexes	European Union, Atkins	2016
	Sector reform and utility commercialization	United States Agency for International Development	2015
	Copperbelt energy corporation annual report	Copperbelt Energy Corporation	2014 - 2016
	Regulated electric and gas networks	Moody's Investor Service	2014
	Zambia renewables readiness assessment	International Renewable Energy Agency	2013
	Power system development masterplan	Japanese International Cooperation Agency	2010
	Mini-grid factsheet	Japanese International Cooperation Agency	2010
	Zambia rural electrification report	United States Agency for International Development	2005
	Renewable Energy Market Landscape Study for Southern and East Africa	Danish Energy Management & Esbensen	2017
	Off-grid Country Briefing	Overseas Development Institute	2013